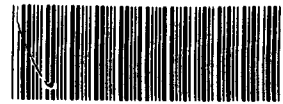


NOTICE

All drawings located at the end of the document.



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**Phase I IM/IRA Decision Document for
Present Landfill Operable Unit No. 7**

Preliminary Draft Report

June 26, 1995

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Golden, Colorado

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OU 7 Help Analysis Evaluation of Cover Components

1. Introduction

Operable Unit (OU) No 7 is one of 16 OUs at the Rocky Flats Environmental Technology Site (RFETS) in Jefferson County, Colorado. Each OU is made up of a number of individual hazardous substance sites (IHSSs). OU 7 comprises the Present Landfill (IHSS 114), the Inactive Hazardous Waste Storage Area (IHSS 203), the East Landfill Pond, the Pond Area Spray Field (IHSS 167 2), and the South Area Spray Field (IHSS 167 3). Figure 1-1 is a 1991 photograph that shows the Present Landfill, East Landfill Pond, and the adjacent spray evaporation areas.

As a result of the production of nuclear weapon components, processing of radioactive substances, and fabrication of metals, hazardous substances have been released at Rocky Flats. A Phase I Resource Conservation and Recovery Act (RCRA) facility investigation/remedial investigation (RFI/RI) was conducted at OU 7 from November 1992 through April 1993 to characterize the site physical features, describe contaminant sources, and determine the nature and extent of contamination in soils resulting from such releases. A Phase II RFI/RI was subsequently planned to characterize the nature and extent of contamination in surface water, groundwater, and air and evaluate contaminant migration pathways.

These activities were initiated pursuant to an Interagency Agreement (IAG) among the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE) dated January 22, 1991 (DOE 1991a). The IAG program developed by DOE, EPA, and CDPHE addresses RCRA and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) issues that pertain to the site. CDPHE is the lead regulatory agency for the IAG program at OU 7.

Prior to completion of the Phase I RFI/RI and initiation of the Phase II, the focus of investigations at OU 7 changed due to the adoption of a presumptive-remedy strategy for streamlined site characterization and site remediation by DOE, CDPHE, and EPA. As a result of this strategy, the Phase I RFI/RI report and Phase II work plan were combined into a single document, the Final Work Plan Technical Memorandum for OU 7 (OU 7 Final Work Plan) (DOE 1994a), which was approved in September 1994. The streamlined Phase II field investigation was conducted from October 1994 through January 1995. Findings of the Phase II field investigation are presented in this report.

In accordance with a Resolution of the Senior Executive Committee of the IAG in April 1994 (DOE 1994b), two interim measure/interim remedial actions (IM/IRAs) are required for OU 7. These include a separate IM/IRA for collection of leachate at the seep above the East Landfill Pond and an IM/IRA for closure of the Present Landfill.

The seep collection IM/IRA is being implemented before closure as an accelerated action. The original conceptual design was for a temporary seep collection system consisting of collection pipe, a precast manhole base section, and a submersible pump. Seep water would be pumped to storage tanks on the divide north of the pond. Water would be trucked to the existing OU 1 treatment facility. This design was presented in the Seep Collection and Treatment Proposed Action Memorandum (PAM), approved by CDPHE and EPA in March 1995 (DOE 1995a). The design and the PAM were modified in June 1995. The modified conceptual design is discussed in Section 1.3.

1.1 Purpose of Report

This Phase I IM/IRA Decision Document (IM/IRA DD) presents the proposed alternative for landfill closure. The alternative addresses all source areas with risk levels greater than $1\text{E-}06$ or a hazard index greater than 1. As agreed to by DOE, CDPHE, and EPA, the interim action will be the final action for closure of OU 7. The IM/IRA DD was prepared in accordance with Paragraphs 15 and 150 of the IAG (DOE 1991a), is consistent with guidance in the preamble to the NCP (55 FR 8704), and is consistent with CHWA closure requirements (6 CCR 1007-3, Part 265).

1.2 Organization of Report

The IM/IRA DD is divided into ten sections as follows:

Section 1, Introduction, discusses the purpose and organization of the report. Other maintenance or remedial actions at the Present Landfill are described, and the project approach is presented.

Section 2, Site Characteristics, describes the physical characteristics and operational history of OU 7, discusses site-specific geology, hydrology, and ecology including sensitive habitats and endangered species, and summarizes the nature and extent of contamination in all media. Information included in this section is from both the Phase I RFI/RI (DOE 1994a) and the Phase II field investigation.

Section 3, Site Risks, outlines the preliminary objectives of the remedial action, presents a conceptual site model for defining risks, summarizes the results of focused risk assessments for various environmental media, assesses compliance with applicable or relevant and appropriate requirements (ARARs), and presents final remedial action objectives (RAOs).

Section 4, Identification and Screening of Technologies, identifies and screens general response actions (GRAs) and technologies that satisfy the RAOs. Screening is based on an evaluation of effectiveness, implementability, and cost. Favorable technologies are retained for consideration in the development of alternatives.

Section 5, Development of Alternatives, describes the general components of the alternatives developed, presents nine alternatives, summarizes the results of the alternatives screen using effectiveness, implementability, and cost, and presents the four alternatives that will be retained for detailed analysis

Section 6, Detailed Analysis of Alternatives, presents an evaluation of the four alternatives using the nine CERCLA criteria (overall protection of human health and the environment, compliance with ARARs, long-term effectiveness and permanence, reduction of toxicity, mobility, and volume through treatment, short-term effectiveness, implementability, costs, and regulatory and community acceptance), and recommends the best alternative for final selection by CDPHE and EPA

Section 7, Proposed Action, describes existing conditions at the landfill, discusses how the proposed action will meet regulatory criteria, and presents the conceptual design for the proposed action. The conceptual design includes the proposed grading plan, surface-water control, proposed cover section, seepage control, gas control, and ancillary facilities

Section 8, Closure and Post-Closure Plans, details the plans that will be carried out during the closure and post-closure care periods to meet regulations stipulated by 6 CCR 1007-3 Section 265.11 and 265.117-120, respectively

Section 9, Environmental Assessment, includes an evaluation of the impacts of the remedial action on human health, wildlife and vegetation, sensitive habitats and endangered species, wetlands and floodplains, air quality, surface-water quality, groundwater quality, irreversible and irretrievable resources, transportation, and cultural resources. Cumulative impacts are examined. Impacts of the preferred alternative are compared to the no-action alternative

Section 10, References, presents references cited in the report

Supporting data are included in the appendices to the report. Appendix A presents borehole geologic logs in LOGGER format from the Phase II field investigation. Appendix B contains drawdown recovery test data from the Phase II field investigation and analytical solutions. Appendix C contains input data, results, and a summary of the groundwater modeling. Appendix D presents the screening-level ecological risk assessment for the leachate seep and surface water and sediment in the East Landfill Pond. Appendix E contains input data, results, contaminant distribution maps, and a summary of the contaminant-transport modeling. Appendix F presents input parameters, results, and a summary of the HELP modeling. Appendix G presents settlement estimates. Appendix H presents gas-emission estimates. Appendix I presents annual soil-loss calculations. Appendix J presents costs.

1.3 Other Maintenance or Remedial Actions

Several other actions are planned in support of closure of OU 7 including implementing a leachate collection and treatment system, constructing a slurry wall on the north side of the landfill, and abandoning groundwater-monitoring wells within the landfill

A passive leachate collection and treatment system is proposed as an accelerated action to eliminate discharge of F039 RCRA-listed waste from the leachate seep to the East Landfill Pond. The action was proposed in the Modified Passive Seep Collection and Treatment Proposed Action Memorandum (PAM), which was submitted to CDPHE and EPA on June 15, 1995. The PAM includes a description of the collection and passive treatment components of the system and a conceptual design. Leachate will be intercepted with perforated pipe, directed to a concrete manhole, and discharged to a reactor tank containing carbon-based granular media. Treated water will be discharged directly to the East Landfill Pond. The system will be fully operational within six months of approval of the revised PAM.

A slurry wall will be constructed on the north side of the landfill as a maintenance action to address the failure of the existing groundwater-intercept system and north slurry wall. Failure of the existing system is evidenced by (1) insignificant heads in wells that straddle the existing groundwater intercept system, (2) groundwater modeling which shows that inflow occurs on the north side of the landfill (see Appendix C), (3) as-built diagrams which reveal that sections of the system were not keyed into bedrock, and (4) as-built diagrams which show that minimum slopes could allow sediment buildup and blockage within the pipe drain. The new slurry wall will reduce groundwater inflow, leachate generation, and outflow at the seep. The length of the slurry wall is estimated at 2,000 feet. The slurry wall will be keyed into weathered bedrock consisting of siltstones and claystones of the undifferentiated Arapahoe and Laramie formations. Depth of the slurry wall varies with the depth of weathered bedrock and ranges from 15 to 30 feet. Hydraulic conductivity of the weathered bedrock is $1\text{E-}06$ centimeters per second (cm/sec). Construction of the slurry wall will occur in late 1995.

Twenty-six of the 54 existing monitoring wells in OU 7 that are sampled quarterly as RCRA compliance wells or sitewide groundwater protection wells were proposed for abandonment. The action was proposed in a January 13, 1995, letter from DOE to CDPHE and EPA (DOE 1994c). CDPHE approved the well abandonment proposal on February 13, 1995 (CDPHE 1995a). Well abandonment was proposed on the basis that the purpose of each well has been fulfilled, the wells fall under the footprint of the landfill cap, the presence of the wells would compromise the integrity of the cap because holes would have to be cut in the synthetic liner, and unequal compaction of

the fill material around the wells would potentially cause differential settlement of the cap Well abandonment will be performed in early 1996

1.4 Project Approach - the Presumptive Remedy

Presumptive remedies are preferred technologies for common categories of sites developed by EPA based on historical data from successful remedial actions at similar sites The objective of the presumptive remedy approach is to streamline the site investigation and remedial action selection and reduce the cost and time required to implement the remedial action The presumptive remedy approach was adopted by DOE, CDPHE, and EPA in May 1994 (EG&G 1993a, DOE 1994d) Letter approval was received from CDPHE in October 1994 (CDPHE 1994a)

The approach was used to streamline the Phase II field investigation, which focused on gathering data for design of the presumptive remedies and assessment of contamination in groundwater downgradient of the landfill As a result of this strategy, a separate Phase I RFI/RI report and comprehensive baseline risk assessment were no longer required Use of the presumptive remedy also eliminated the need for initial identification and screening of alternatives for the corrective measures study/feasibility study (CMS/FS), or IM/IRA, and allowed the schedule to implement remedial actions and achieve final closure to be accelerated

The presumptive remedy for CERCLA municipal landfill sites is containment (EPA 1993a) Containment technologies are generally appropriate for municipal landfills because the waste poses a relatively low long-term threat and the volume and heterogeneity of the waste make treatment impracticable The containment presumptive remedy consists of the following components

- institutional controls
- landfill cap
- landfill gas control (and treatment if necessary)
- leachate collection (and treatment if necessary)
- source area groundwater control

The presumptive remedy limits the universe of alternatives requiring detailed analysis to the components listed above Response actions selected for individual sites include only those components necessary based on site-specific conditions (EPA 1993a) The containment presumptive remedy addresses all pathways associated with the source Characterization of the waste material within the landfill is not necessary for selecting a response action

Potentially affected media and exposure pathways outside the landfill must be addressed separately For OU 7, potentially affected media include the following

- surface water in the East Landfill Pond
- sediments in the East Landfill Pond
- surface soils in spray evaporation areas
- subsurface geologic materials downgradient of the landfill
- groundwater downgradient of the source area

A response action for potentially affected media and exposure pathways outside of the source area may be selected together with the presumptive remedy to develop a comprehensive site response. The nature and extent of contamination in potentially affected media is addressed in the following section. A focused risk evaluation and an ARARs comparison for these media are presented in Section 3.



Figure 1-1
Present Landfill and East Landfill Pond (June 1991)

2. Site Characteristics

Sections 2.1 through 2.5 describe the physical characteristics and operational history of OU 7, geology, surface-water and groundwater hydrology, ecology, and nature and extent of contamination. Much of the information in these sections is taken from the OU 7 Final Work Plan (DOE 1994a).

2.1 Description and Operational History of OU 7

OU 7 lies north of the industrial area on the western end of No Name Gulch. Individual Hazardous Substance Sites (IHSSs) and historical interim response actions are shown in Figure 2-1. OU 7 includes the Present Landfill (IHSS 114), Inactive Hazardous Waste Storage Area (IHSS 203), asbestos disposal areas, and the East Landfill Pond and adjacent spray evaporation areas (IHSSs 167.2 and 167.3). In addition, a surface-water diversion system, groundwater-intercept system, and leachate-collection trench, which are historical interim actions, lie within OU 7. Historical data used to describe OU 7 were compiled from previous landfill investigations (Rockwell International 1988a, Rockwell International 1988b, Rockwell International 1988c, DOE 1991b), the historical release report (DOE 1992a), and data from the Phase I RFI/RI field investigation (DOE 1994a).

2.1.1 Present Landfill (IHSS 114)

Operation of the Present Landfill began on August 14, 1968, and is expected to continue until the new landfill opens in 1997. The Present Landfill began as a portion of the natural drainage at the headwaters of No Name Gulch was filled with soils from an onsite borrow area to a thickness of approximately 5 feet to construct a surface on which to start landfilling. Waste delivered to the landfill was spread across the work area, compacted, and covered with soil (DOE 1994a).

In 1986 and 1987, studies were conducted to identify waste streams generated at the plant under the Waste Stream Identification and Characterization (WSIC) program. Of the 338 identified waste streams disposed in the landfill, 97 contained hazardous waste or hazardous constituents. As of November 1986, waste streams identified as hazardous were no longer disposed in the landfill. In 1989, waste streams were further characterized under the Waste Stream Residue Identification and Characterization (WSRIC) program. Of the 183 identified waste streams disposed in the landfill since 1989, none are hazardous (DOE 1994a).

Nonhazardous waste streams disposed in the landfill include office trash, paper, rags, personal protective equipment, demolition materials, construction debris, scrap metal,

empty drums and containers, used filters, electrical components, dried sanitary-sewage sludge, and solid sump sludge. These sludges may have been radioactively contaminated (plutonium and depleted uranium). Hazardous waste streams disposed in the landfill include containers partially filled with paint, solvents, degreasing agents, and foam polymers, wipes and rags contaminated with these materials, paint and oil filters, and metal cuttings and shavings coated with hydraulic oil and carbon tetrachloride (DOE 1994a). The landfill was also the site of polychlorinated biphenyl (PCB) storage and asbestos disposal (see Sections 2.1.2 and 2.1.3).

Based on the areal and vertical extent of waste and soil cover, the total volume of material in the landfill was estimated to be 415,000 cubic yards (cy) in 1994 (DOE 1994a). This volume was determined by 36 cone-penetration tests on a grid within the landfill. Assuming that approximately 30 percent of the total material deposited in the landfill is soil cover, the volume of waste in the landfill is approximately 291,000 cy. The waste is generally thinnest along the boundaries and thickest along the east-west axis of the landfill. The thickness of waste material ranges from less than 1 foot to approximately 40 feet near the east face of the landfill, which coincides with the deepest portion of the original drainage. Waste material has not been placed beyond the clay barrier in the groundwater-intercept system or the slurry walls. By closure in 1997, the total volume of waste and fill material will be 540,000 cy.

Five gas vents are present within the operating landfill (Figure 2-1). These vents are constructed of polyvinyl chloride (PVC) and project above the ground surface approximately 5 feet. The vents were installed in June 1992 to release landfill gases generated by microbial degradation of organic waste. The composition, quantity, and generation rates of the gases depend on factors such as waste quantity and composition, waste placement characteristics, landfill thickness, moisture content, and amount of oxygen present. Carbon dioxide is the principal gas generated during early stages of waste burial, as the waste undergoes aerobic microbial degradation. As oxygen is depleted, anaerobic microbial degradation produces methane and carbon dioxide.

Leachate from landfills is a product of natural biodegradation, infiltration of precipitation, and migration of groundwater through waste (EPA 1991a). Leachate has been forming since the landfill opened in 1968. Infiltration at the ground surface and inflow of groundwater upgradient are the primary sources of water to the landfill. The volume of leachate within the landfill is expected to vary as the potentiometric surface fluctuates in response to infiltration of precipitation through the interim soil cover. The volume is expected to decrease after the landfill cap and slurry wall are in place. The depth to leachate within the landfill is approximately 20 feet at the western end, 16 feet in the middle, and 33 feet at the eastern end near the seep. Leachate presently discharges from a seep (SW097) located at the base of the east face of the landfill (Figure 2-1).

2 1 2 Inactive Hazardous Waste Storage Area (IHSS 203)

The Inactive Hazardous Waste Storage Area is located at the southwest corner of the Present Landfill (Figure 2-1). The area was actively used between 1986 and 1987 as a hazardous-waste storage area for both drummed liquids and solids. Fifty-five-gallon drums containing liquids were stored in cargo containers, drums containing solids were stored outside cargo containers on the ground. RCRA-listed wastes were stored in 12 of the cargo containers and included solvents, coolants, machining wastes, cuttings, lubricating oils, organics, and acids. PCB-contaminated soil, debris, and transformer oil were stored in the other two cargo containers. All drums and cargo containers were removed in May 1987. Hazardous materials are no longer stored at the site (DOE 1994a).

Soil-gas and surface-soil sampling was conducted at IHSS 203 during the Phase I RFI/RI. Soil-gas samples were collected at 35 locations at approximately 5 feet below ground surface and analyzed for volatile organic compounds (VOCs) (Appendix C, DOE 1994a). Concentrations of VOCs in soil gas varied significantly within the sampling area and distinct sources were not identified that could be confidently interpreted as contamination associated with spills or releases during waste storage activities. Because landfill wastes underlie IHSS 203, VOCs in soil gas in this area are probably associated with the landfill (DOE 1994a).

Surface-soil samples were collected at 49 locations from the 0- to 2-inch soil horizon and 18 locations from the 0- to 10-inch soil horizon. Samples were analyzed for PCBs, metals, and radionuclides. Two PCBs (Aroclor-1254 and Aroclor-1260) were detected at low concentrations in approximately 20 percent of the soil samples but are not present at depth. All but one of the results for the analysis of PCBs in soil from IHSS 203 were J qualified, denoting estimated PCB concentrations below the detection limit of 230 $\mu\text{g/kg}$. Metals and radionuclides were generally detected at concentrations or activities less than two times the maximum background concentration or activity (DOE 1994a).

2 1 3 Asbestos Disposal Areas

Beginning in 1985, asbestos generated onsite was reportedly disposed in a designated 10-foot-deep pit located east of the landfill. The asbestos-containing material was placed in heavy plastic bags, disposed in the pit, and covered with soil when the pit became full. By December 1988, asbestos was disposed in several pits (Figure 2-1). Records indicate that disposal of asbestos continued until April 1990 (DOE 1994a).

Asbestos-disposal areas are presently delineated with warning signs. Bags of friable asbestos were disposed in the northern trench, and it is reported that some of the bags burst during disposal (Blaha 1994). Unused molds for plutonium pits were disposed in

the southern trench (Blaha 1994) It is unclear if asbestos was also disposed in the southern trench Aerial photographs show that waste material was buried in the vicinity of the asbestos-disposal pits, this area is included in the waste-volume calculations

During the Phase I RFI/RI, the asbestos disposal pits were located and two soil samples were collected and analyzed for asbestos (Appendix C, DOE 1994a) A trace (less than one percent) of chrysotile asbestos was detected in the surface soil (DOE 1994a) No intrusive work was performed in these areas and the ground surface appears to be undisturbed

2 1 4 Historical Interim Response Actions

In 1973, tritium and strontium were detected in leachate draining from the landfill Interim response actions were undertaken to control the generation and migration of landfill leachate (DOE 1994a) These included construction of a surface-water diversion ditch around the perimeter of the landfill, two detention ponds immediately east of the landfill, a subsurface intercept system for diverting groundwater around the landfill, and a subsurface leachate-collection trench (Figure 2-1) The trench for the leachate-collection and groundwater-intercept system varies in depth from 10 to 20 feet Construction began in October 1974 and was completed in January 1975

A surface-water diversion ditch was constructed around the perimeter of the landfill in October 1974 to divert surface-water runoff around the landfill and reduce the infiltration of surface water into the landfill, thereby reducing the volume of leachate draining from the landfill (Figure 2-1) No waste disposal is known to have occurred outside of the surface-water diversion ditch

As part of the original interim-response action two detention ponds were constructed in 1974 to control leachate generated by the landfill (DOE 1994a) These ponds were formed by constructing temporary berms across the drainage immediately downstream of the landfill The West Landfill Pond impounded leachate generated by the landfill The East Landfill Pond provided a backup system for any overflow from the West Landfill Pond and was also used to collect intercepted groundwater as needed or the slurry walls (DOE 1992a)

A more permanent embankment was eventually constructed for the East Landfill Pond The new embankment was an engineered dam structure with a spillway designed to retain the majority of the water in the channel A low-permeability clay core keyed into bedrock was constructed within the embankment to reduce seepage (DOE 1994a)

A groundwater-intercept system was installed around the perimeter of the landfill in 1974 as an interim-response action to divert groundwater around the landfill and thus

control generation and migration of leachate (Figure 2-1) The groundwater-intercept system is a clay barrier (not a slurry wall) on the outside wall of the leachate-collection trench with a perforated pipe outside the barrier to carry groundwater to the groundwater-intercept system discharge points (Figure 2-2)

Between 1977 and 1981, the leachate-collection trench and the West Landfill Pond were buried beneath waste during landfill expansion In 1982, two soil-bentonite slurry walls were constructed near the eastern end of the landfill to prevent groundwater migration into the expanded landfill area These slurry walls were tied into the north and south arms of the groundwater-intercept system and extend approximately 900 feet from the points of intersection (Figure 2-2) Based on as-built drawings, the slurry walls vary in depth from 10 to 20 feet There is no known waste disposal outside of the clay barrier or the slurry walls (DOE 1994a)

Effectiveness of landfill structures was evaluated in 1994 for the Phase I RFI/RI using historical groundwater elevation data along a number of transects These data indicate that the groundwater-intercept system is functioning effectively except on the northwest side of the landfill (DOE 1994a)

As-built diagrams were reviewed for the IM/IRA decision document Approximately 275 feet of the leachate-collection system trench along the northwest side and 400 feet of the trench along the southwest side of the landfill are not keyed into bedrock These diagrams establish a possible pathway that allows groundwater to flow into the landfill on the northwest side Another possible mechanism is cracking in the clay layer Any blockage in the drain outside the clay barrier would further reduce the effectiveness of the intercept system Because there is a groundwater divide just south of the landfill, the head on the south side of the landfill is fairly low and the groundwater intercept system does appear to be functioning, even though it is not keyed into bedrock

2.1.5 Spray Evaporation Areas (IHSSs 167.2 and 167.3)

Spray evaporation of water from the East Landfill Pond along the north and south banks of the pond to maintain the volume at 75 percent capacity (approximately 5,500,000 gallons) began in September 1975 Spray evaporation was discontinued in 1994 Two discrete areas have been identified (Figure 2-1) the Pond Area Spray Field (IHSS 167.2) and the South Area Spray Field (IHSS 167.3) These IHSSs were originally in OU 6, but were transferred to OU 7 in 1994 (DOE 1994a) Dimensions of the spray fields are approximately 100 feet by 460 feet for IHSS 167.2 and 120 feet by 440 feet for IHSS 167.3 Surface soils downgradient of the East Landfill Pond dam are downwind and thus potentially affected by spray activities in these areas

2.2 Geology

The geology at OU 7 is a function of the regional tectonic setting and local depositional and erosional conditions. Geologic data used to characterize OU 7 were compiled from previous landfill investigations (Rockwell International 1988a, DOE 1991b), existing geologic characterization reports (EG&G 1992a, EG&G 1995a), U.S. Geological Survey publications (Spencer 1961, Van Horn 1972), Colorado School of Mines reports (Weimer 1976), data from the Phase I RFI/RI field investigation (DOE 1994a), and data from the Phase II field investigation. A summary of the general geologic framework, description and distribution of surficial and bedrock geologic units, discussion of geotechnical properties, and a description of pond sediments are presented in the following sections. Geologic borehole logs from the Phase II field investigation are presented in Appendix A. Geologic borehole logs from the Phase I RFI/RI are presented in Appendix E in the OU 7 Final Work Plan (DOE 1994a).

2.2.1 General Geologic Framework

The Rocky Flats site is located on an eastward sloping plain just east of the Colorado Front Range. The surface cover is composed of a series of coalescing alluvial fans that were developed during the Pleistocene. The Present Landfill is located near the eastern extent of the alluvial-fan deposits. The alluvial fans were deposited on a broad, gently sloping erosional surface, or pediment. The pediment is underlain by more than 10,000 feet of gently dipping (less than 2 degrees) Pennsylvanian to Upper Cretaceous sedimentary rocks.

Dissection of the gravel-capped pediment has occurred by headward erosion and planation along eastward-flowing streams and their tributaries. Fluvial processes have formed moderately steep hillsides adjacent to the stream drainages, with the steepest slopes formed along the tops of the incised drainages. The landfill at OU 7 is located in No Name Gulch at the western limit of headward erosion and pediment dissection. Waste material has been placed on top of the bedrock and fills the valley to the top of the pediment at approximately 6000 feet. Waste material is confined laterally by the leachate collection trench and slurry walls and by the bedrock slopes of the valley.

Figure 2-3 presents a generalized stratigraphic section that shows the vertical sequence of surficial deposits and bedrock. Surficial and bedrock geologic units that influence groundwater flow include the Rocky Flats Alluvium and the underlying Arapahoe and Laramie formations. Also important is the artificial fill material of the landfill, which is not shown on the figure. The Fox Hills Sandstone occurs at a depth of approximately 700 to 800 feet, which is too deep to be affected by the landfill. As such, it is not described.

Figure 2-4 shows the lateral distribution of surficial geologic material at OU 7. Figure 2-5 shows the location of cross-section lines. Two cross sections (Figures 2-6 and 2-7) illustrate the lateral and vertical relationships of surficial and bedrock units. The base of waste material, contact between alluvium and weathered bedrock, contact between weathered and unweathered bedrock, and potentiometric surfaces are shown on the cross sections. Horizontal and vertical scales of the cross sections are 1 inch equals 50 feet so there is no vertical exaggeration.

2.2.2 Description of Geologic Units

Surficial material consists of Quaternary alluvial-fan deposits of the Rocky Flats Alluvium, colluvial deposits, alluvial deposits of the valley-fill alluvium, and artificial fill (Figure 2-4). All surficial deposits are part of the upper hydrostratigraphic unit (UHSU) at Rocky Flats, which is discussed in more detail in Section 2.3.

The Rocky Flats Alluvium caps the divides north and south of No Name Gulch and was deposited as a series of coalescing alluvial fans. Thickness of the Rocky Flats Alluvium is 25 to 30 feet in wells on the northwest, west, and southwest sides of the landfill, and 10 to 15 feet in wells on the divides north and south of the East Landfill Pond. The Rocky Flats Alluvium is composed of reddish-brown to yellowish-brown, well graded, coarse gravel in a clayey-sand matrix. Pebbles and cobbles are composed of quartzite, granite, and gneiss. Maximum pebble size ranges from 1 to 3 inches in diameter. Caliche was described in drill cores from the divide north and south of the East Landfill Pond. These zones may be discharge points for alluvial groundwater along the hillsides above the pond.

Colluvium covers the hillsides between the pediment on which the Rocky Flats Alluvium is deposited and the No Name Gulch drainage or the East Landfill Pond. Colluvial materials have been deposited by slope wash and downward creep of alluvial material and bedrock. The colluvium is 1 to 5 feet thick on the slopes around the East Landfill Pond and below the dam. The colluvium consists of brown, structureless clay with some sand and a trace gravel. Soil development has occurred and roots are present down to depths of 3 feet.

Valley-fill alluvium is present in the No Name Gulch drainage downstream of the East Landfill Pond and is derived from reworked alluvial material and bedrock. The alluvium is 3- to 8-feet thick in the OU 7 area and becomes thicker downstream to the east. The alluvium consists of brown, laminated to structureless clay with lenses of gravel. Gravels have a sandy-silt matrix that is often iron-stained.

Artificial fill and disturbed surficial material are present within the boundaries of the landfill, which includes IHSS 203 and the asbestos-disposal areas. Thickness of the artificial fill, which includes waste and interim-soil cover, ranges from approximately 5

to 45 feet. Artificial fill is thickest near the centerline of the valley and thinnest around the perimeter of the landfill, inside the surface-water diversion ditch. An actively slumping area occurs in the artificial-fill material on the northeast side of the landfill. Seeps were observed along the slope in this area.

Bedrock unconformably underlies the surficial deposits and consists of claystones, siltstones, and fine-grained sandstones of the undifferentiated Upper Cretaceous Arapahoe and Laramie formations (Figure 2-3).

In general, the base of the Arapahoe Formation, which unconformably overlies the Laramie Formation, is marked by the presence of medium-grained to conglomeratic sandstones composed of well-rounded, frosted, quartz sand grains with pebbles of chert, rock fragments, and ironstone. The lowermost 20 feet of the Arapahoe Formation is shown underlying the Rocky Flats Alluvium on the divides north and south of the unnamed tributary to No Name Gulch (EG&G 1992a, EG&G 1995a). However, sandstones exhibiting the distinctive characteristic of the basal Arapahoe Formation or No. 1 sandstone (Figure 2-3) are not exposed at the surface nor in any of the drill cores from OU 7. The contact between the Arapahoe and Laramie formations is difficult to interpret in the absence of the marker or No. 1 sandstone bed. Therefore, in this report, the Arapahoe and Laramie formations are undifferentiated. However, in the No Name Gulch drainage the elevation of the bedrock is low enough that the bedrock is likely Laramie Formation.

The Laramie Formation is approximately 600 to 800 feet thick. The lower 300 feet is composed of laterally extensive sandstones, kaolinitic claystones, and coal beds. The upper 300 to 500 feet consists primarily of olive-gray and yellowish-orange claystones. Four sandstone units (designated as the No. 2, No. 3, No. 4, and No. 5 sandstones) have been identified in the bedrock beneath the No. 1 sandstone and are considered upper Laramie Formation (Figure 2-3) (EG&G 1992a, EG&G 1995a). Where present, the sandstones are olive gray, very fine-grained, subangular, well-sorted, locally calcareous, silty, and clayey. Because they lie within claystones and they are not in hydraulic connection with either the No. 1 sandstone or the surficial deposits, the No. 2 through No. 5 sandstones are probably not significant migration pathways for potential contaminants to groundwater (DOE 1994a).

The bedrock at OU 7 is composed of gray to brown, structureless claystones containing a trace of carbonaceous material and occasional thin interbeds of siltstone and, less frequently, fine-grained sandstone. Sandstones are composed of gray, very fine- to fine-grained, subangular to subrounded, well sorted, quartzose sand. Sandstones are frequently interbedded with siltstones. These "coarser-grained" units vary from 10 to 30 feet thick.

2 2 3 Distribution of Geologic Units

Geologic units beneath the landfill waste consist of a thin covering of colluvium on hillsides and valley-fill alluvium in the No Name Gulch drainage, both underlain by the Laramie Formation. Lithologies of the colluvium are clays and silts. Lithology of the valley-fill alluvium is gravelly, clayey sand. Lithologies of the Laramie Formation are typically limited to claystones and siltstones. Laramie Formation sandstones (sometimes referred to as the No 2 through No 5 sandstones) were identified in well 0886, located near the East Landfill Pond, and in wells 4187, B207089, B207189, and 53094, located in No Name Gulch downgradient of the dam.

Fine-grained sandstones subcrop beneath the alluvium only at well location B207089, which is downgradient of the East Landfill Pond (Figure 2-5). This sandstone pinches out approximately 500 feet downstream and is not present at well 4287. Shallow sandstones (present within 15 feet of the contact between alluvium and bedrock) were encountered in wells 6487 (25 feet), located within the landfill on the south side, and B206789 (8 feet), located on the southwest shore of the pond. Based on a 2-degree regional dip, these shallow sandstones will not subcrop in the OU 7 area and are not preferential pathways for migration of contaminants (DOE 1994a).

Geologic units on the groundwater divides adjacent to the landfill consist of Rocky Flats Alluvium, underlain by the undifferentiated Arapahoe and Laramie formations (Figures 2-6 and 2-7). Lithologies of the Rocky Flats Alluvium are clayey gravels and sands. Lithologies of the undifferentiated Arapahoe and Laramie formations are typically limited to claystones and siltstones. Laramie Formation sandstones were identified in wells 0986, 50294, 50594, and 50894 at depths of 50 to 125 feet below ground surface. All of these wells are located upgradient of the landfill.

A possible fault was identified in the OU 7 area during the 1995 Sitewide Geoscience Characterization Study (EG&G 1995a). The inferred fault, which is over two miles long, trends northeast-southwest and cuts across OU 7 east of the landfill face near the edge of the East Landfill Pond (Figure 2-4). The fault plane dips to the west. Displacement along the fault is reported to be 25 to 50 feet, based on structural offset of a marker bed (EG&G 1995a). A trench excavated across the northern end of the fault revealed a wide fracture zone in the bedrock, however, the fractures appeared to decrease with depth. The surficial deposits were not offset, suggesting that movement had not occurred since their deposition in the Quaternary (EG&G 1995a).

2 2 4 Geotechnical Properties

Selected samples from subsurface boreholes drilled near the alignment of the proposed slurry wall were tested to determine geotechnical properties of soils developed in alluvium and colluvium at these locations. Samples of soils developed in alluvium

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from boreholes 53494 and 53594 and soils developed in colluvium from boreholes 53694 and 52794 were submitted for testing (Figure 2-5). Tests performed included natural moisture content in accordance with standard method ASTM D2216, grain size distribution using sieve and hydrometer testing in accordance with standard method ASTM D422, Atterberg limits in accordance with standard method ASTM D4318, and specific gravity in accordance with standard method ASTM D854.

A summary of the geotechnical classification is presented in Table 2-1. Test results from boreholes 53494 and 53594 indicate that the shallow soils at these locations are classified as clayey sand, based on the Unified Soil Classification System (USCS) in accordance with standard method ASTM D2487-83. Test results from boreholes 53694 and 52794 indicate that the shallow soils at these locations are classified as fat clay, based on the USCS. The clayey sand and fat clay determinations are generally consistent with descriptions of alluvium and colluvium, respectively, used to describe these soils.

2.2.5 Description of Pond Sediments

Sediments have been accumulating in the East Landfill Pond since its construction in 1974. The source of contaminant loading to pond sediments includes the leachate seep and surface-water runoff from surrounding slopes. Sediment in the East Landfill Pond was sampled and characterized during the Phase I RFI/RI (DOE 1994a). The sediment ranges from 0.5- to 0.8-foot thick and consists of clay, silt, and organic matter. The upper 0.2 to 0.5 feet consists of black silt and clay with very fine roots occurring in either thin mats or scattered throughout the core. No bedding or lamination were visible. The remaining 0.3 to 0.4 feet of core consists of very dark gray clay with some silt. Very fine roots were observed but they decreased with depth. Olive gray claystone of the Laramie Formation underlies the pond sediment.

2.3 Hydrology

The hydrology at OU 7 is a function of the general geologic framework, recharge and discharge conditions, physical properties of the aquifer materials, hydrodynamic conditions, and landfill structures. Hydrogeologic data used to characterize OU 7 were compiled from previous landfill investigations (DOE 1991b), sitewide groundwater monitoring, assessment, and protection plans and reports (EG&G 1990a, EG&G 1991a, EG&G 1994a, DOE 1992b, and DOE 1993a), and water-level measurement and hydraulic conductivity test activities of the Phase I and Phase II RFI/RI field investigations (DOE 1994a). A detailed examination of the hydrogeology at OU 7 is presented in the OU 7 Final Work Plan (DOE 1994a).

2 3 1 Conceptual Flow Model

The conceptual flow model for OU 7 is illustrated in Figure 2-8 and encompasses surface-water hydrology, interactions between surface water and groundwater, and groundwater hydrology

- Surface water hydrology components of the conceptual model include precipitation, evapotranspiration, pond evaporation, surface water runoff, and engineered water transfers
- Interactions between surface-water flow and groundwater flow include infiltration/percolation, interflow, seep flow at SW097, groundwater baseflow into the pond, discharge from the existing groundwater-intercept system into the pond, and seepage flow downward out of the pond
- Groundwater hydrology components include groundwater flow in surficial materials, seepage between surficial materials and weathered bedrock, groundwater flow in weathered bedrock, seepage between weathered bedrock and unweathered bedrock, and groundwater flow in unweathered bedrock

Recharge, discharge, and interactions between the surface-water and groundwater components of the conceptual model are presented briefly here and discussed in more detail in the following sections

Recharge or infiltration/percolation is a significant source of water to the landfill mass. Groundwater inflow under or through the existing groundwater-intercept system is another significant source of water to the landfill. These two sources of inflow are quantified in a water balance performed using numerical modeling, which is discussed in more detail in Section 2 3 5 and Appendix C. Outflow from the landfill mass is funneled to the vicinity of the seep at SW097 where it exits the landfill as either seep flow or groundwater baseflow. The East Landfill Pond collects surface-water runoff, seep flow, and groundwater baseflow. The dam acts as a barrier to the flow of groundwater in surficial materials. Flow in the weathered bedrock is much less than the flow in surficial materials. Some preferential flow paths, most likely in the form of fractures, exist in the weathered bedrock. These preferential flow paths are potential contributors to the migration of contaminants in weathered bedrock. Flow in unweathered bedrock is so small that diffusion controls any potential contaminant transport.

2 3 2 Surface-Water Hydrology

Surface-water features resulting from historical interim response actions control surface-water hydrology. Individual components of surface-water hydrology shown in the conceptual model (Figure 2-8) are discussed below.

2 3 2 1 *Surface-Water Features*

A surface-water diversion ditch was constructed around the perimeter of the landfill in 1974 to divert surface-water runoff around the landfill and reduce the infiltration of surface water into the landfill, thereby reducing the volume of leachate exiting as seep flow (see Figure 2-1). On the north side of the landfill the ditch runs under a perimeter road through a small culvert and east into a small, natural drainage that eventually joins No Name Gulch below the East Landfill Pond dam. On the south side of the landfill, the ditch runs east above the East Landfill Pond and drops into the unnamed tributary to No Name Gulch below the dam. The ditch is 2- to 3-feet deep and 5-feet wide at the bottom and has a trapezoidal shape. The slopes and floor of the ditch are composed of sparsely vegetated native-soil material.

The pond covers approximately 2.5 acres (see Figure 2-1). Pond water levels are controlled to prevent overflow into the spillway draining to No Name Gulch. Between 1975 and 1994, water volume was reduced to 75 percent capacity (approximately 5,500,000 gallons) by periodic spray evaporation. Spray evaporation operations ceased in 1994. Approximately 1,000,000 gallons of water were transferred from the East Landfill Pond to the A-series ponds in fall 1994. Water was also transferred from the East Landfill Pond to the A-series ponds in May 1995.

The pond water volume fluctuates seasonally but averages approximately 6,000,000 gallons. After water was transferred to the A-series ponds in fall 1994, the pond volume was reduced to approximately 5,000,000 gallons. Recharge to the pond occurs from groundwater baseflow in surficial materials, leachate from the seep, and surface-water runoff from the landfill and surrounding slopes. Discharge occurs by natural evaporation, seepage downward into weathered bedrock, seepage through the clay core of the dam, and engineered water transfers.

2 3 2 2 *Components of the Conceptual Flow Model*

Surface-water hydrology components include precipitation, evapotranspiration, pond evaporation, surface water runoff, and water transfers from the East Landfill Pond to the A-series ponds.

Mean annual precipitation at RFETS, including rainfall and snowmelt, is nearly 16 inches (DOE 1980). Approximately 40 percent of the annual precipitation falls during the months of April, May, and June. An additional 30 percent falls in July and August. Autumn and winter account for 19 and 11 percent of the annual precipitation, respectively.

Pond evaporation is estimated at 70 percent of the pan evaporation, which ranges from 1.24 inches in December and January to 6.76 inches in September (DOE 1994a).

Potential evapotranspiration, which includes both evaporation and transpiration by plants, varies in a pattern similar to that shown by pan evaporation. Potential evapotranspiration data for RFETS are not available. At any given time, precipitation in excess of evapotranspiration will become surface-water runoff, infiltration, or interflow.

Surface-water runoff from the landfill and from the area surrounding the pond are major contributors to pond water (DOE 1994a). Some portion of surface-water runoff is diverted by the surface-water diversion ditch, while a significant fraction flows to the East Landfill Pond.

As stated above, water is periodically transferred to the A-series ponds to control the water level in the East Landfill Pond. Approximately 1,000,000 gallons of water were transferred in fall 1994. Water was also transferred in May 1995.

2.3.3 Interactions Between Surface Water and Groundwater

Interactions between surface water and groundwater include infiltration/percolation, interflow, seep flow at SW097, groundwater baseflow into the pond, discharge from the existing groundwater-intercept system into the pond, and seepage flow downward out of the pond.

Infiltration is the process by which precipitation moves downward into the soil and includes the flow within the unsaturated zone (Freeze and Cherry 1979). For purposes of the conceptual model, water that infiltrates reaches the groundwater table and recharges the groundwater in surficial materials. Infiltration at OU 7 is assumed to be between 5 and 10 percent of the mean annual precipitation (0.8 to 1.6 inches).

Interflow is subsurface flow in the horizontal direction above the water table that is usually associated with storm events on hillsides. Interflow may be a significant contributor to the variability of the flow at the leachate seep (SW097).

Leachate presently discharges from a seep located at the base of the east face of the landfill (see Figure 2-1). Seep flow varies throughout the year and has been estimated between 1 and 7 gallons per minute (gpm). A significant fraction of the groundwater flow from the landfill is funneled toward the seep. The seep is located in the original stream channel in No Name Gulch that was filled in during construction and subsequent waste disposal in the landfill. The seep is also directly downgradient of the West Landfill Pond dam, which was breached before being covered with waste and interim-soil cover. This breached dam may serve to further direct groundwater flow toward the seep. As stated above, interflow is potentially a major source of the variability of the seep flow.

An intermittent seep has been observe north of SW097 on the hillside just below the north asbestos-disposal area. This intermittent seep is most likely caused by saturated materials related to storm events. Heavy surface water runoff has been observed in this area following storm events. Recent slumps have also been described.

Groundwater baseflow exists in surficial materials and weathered bedrock. In surficial materials, the baseflow that does not intersect the ground surface at the seep is a source of recharge to the pond. The saturated thickness of the surficial materials at the edge of the East Landfill Pond is much less than the saturated thickness directly to the west in the landfill (Figure 2-9). This reduction in saturated thickness contributes to the formation of the seep (DOE 1994a). Evidence of preferential flow also exists. The seep flows year-round while nearby alluvial well 0786 is often dry. The groundwater modeling for the site also indicates that preferential flow occurs in the vicinity of the seep (see Appendix C). In weathered bedrock, the potentiometric surface is below the bottom of the pond and the baseflow in the weathered bedrock is not expected to be a source of recharge to the pond.

The existing groundwater intercept system is configured to discharge either to the pond or to the discharge points east of the dam (SW099 and SW100) (see Figure 2-1). Based on observations of no flow at the discharge points east of the dam, it is assumed that the system is currently discharging to the East Landfill Pond. Discharge points to the pond are not visible at the ground surface.

Water seeps from the pond into the weathered bedrock and through the weathered bedrock under the dam. Some water also seeps through the dam core. Both of these flows are expected to be small based on the measured hydraulic conductivities in the weathered bedrock and the dam core (DOE 1994a, EG&G 1993b). This seepage is not effective in recharging the weathered bedrock downgradient of the pond. The weathered bedrock wells directly below the dam (B206889 and B206989) consistently exhibit water levels 12 to 15 feet below the top of bedrock elevation, indicating only partial saturation of weathered bedrock and a "perched" water table condition for surficial materials.

The dam impedes groundwater flow in surficial materials. Particle tracking modeling shows that contaminants from the landfill are intercepted by the pond (see Appendix C). The chemical composition of groundwater downgradient of the dam is statistically different than the groundwater in the vicinity of the East Landfill Pond (see Section 2.5.5 for a discussion of background comparisons and potential contaminants of concern [PCOCs]). The wells in surficial materials directly downgradient of the dam are often dry.

2 3 4 Groundwater Hydrology

Groundwater flow at OU 7 occurs in the UHSU, which consists of surficial materials and weathered bedrock and, to a much lesser extent, in the lower hydrostratigraphic unit (LHSU), which consists of discontinuous sandstone lenses in the unweathered bedrock

2 3 4 1 Groundwater Flow in the UHSU

The UHSU, which corresponds to the uppermost "aquifer" of the groundwater assessment plan (DOE 1993a), is unconfined and consists of saturated, unconsolidated surficial materials and weathered bedrock. As discussed in Section 2 2 1, surficial materials include the Rocky Flats Alluvium, colluvium, valley-fill alluvium, and artificial fill. Weathered bedrock is composed of undifferentiated Arapahoe and Laramie Formation claystones and siltstones. Claystones predominate at OU 7.

Groundwater flow in surficial materials is expected to be significantly greater than groundwater flow in either the weathered bedrock or the unweathered bedrock. Hydraulic conductivities were measured at OU 7 during the Phase I and Phase II field investigations using drawdown-recovery tests. A description of field procedures, data analysis, and results is presented in the OU 7 Final Work Plan (DOE 1994a). Drawdown-recovery test data and analytical solutions from the Phase II field investigation are included in Appendix B. In addition, some slug tests were performed prior to the Phase I investigation. The results from all of these tests were used in calculating the geometric mean of hydraulic conductivities for surficial materials, weathered bedrock, and unweathered bedrock. The location, type of test, result, and geometric mean of results are presented in Appendix B.

The geometric mean of the measured hydraulic conductivities for the different sample populations are as follows: (1) for surficial materials excluding artificial fill, the geometric mean is 1.6×10^{-4} cm/sec or 0.47 feet/day, (2) for artificial fill, the geometric mean is 6.7×10^{-5} cm/sec or 0.19 feet/day, and (3) for all surficial materials combined, the geometric mean is 1.3×10^{-4} cm/sec or 0.36 feet/day. These hydraulic conductivity measurements are significantly greater than the measurements for weathered bedrock or unweathered bedrock. The geometric mean of measured hydraulic conductivities in the weathered bedrock of the Laramie Formation is 4.0×10^{-7} cm/sec or 0.0011 feet/day. The geometric mean of measured hydraulic conductivities in unweathered bedrock is 6.4×10^{-7} cm/sec or 0.0012 feet/day. The individual hydraulic conductivities for each geologic unit are presented graphically in Figure 2-10.

As described in the conceptual model above, sources of groundwater recharge to the UHSU include infiltration/percolation of precipitation, snowmelt, storm runoff, and downward seepage from the East Landfill Pond. Discharge occurs through

evapotranspiration and surface seepage where the water table intersects the ground surface. The level of groundwater rises annually in response to spring and summer recharge and declines during the remainder of the year.

Groundwater in the UHSU generally flows to the east, however, localized flow follows topographic slopes toward the pond or toward the drainage below the dam. Potentiometric surface maps for surficial materials and weathered bedrock for April 1995 are presented in Figures 2-11 and 2-12, respectively. The depth to groundwater in the UHSU is approximately 5 feet in No Name Gulch. Groundwater flows to the east within the valley-fill alluvium, however, flow is intermittent and ephemeral. Certain groundwater-monitoring wells east of the East Landfill Pond dam are often dry.

The depth to groundwater within the landfill is approximately 20 feet at the western end, 16 feet in the middle, and 33 feet at the eastern end near the seep. Relatively high water levels in the middle of the landfill result from groundwater inflow on the north side, as shown by the potentiometric surface map in Figure 2-11. The lower portion of the landfill waste in the original No Name Gulch drainage is saturated in this area. Maximum thickness of saturated waste material is nearly 20 feet.

In the vicinity of the landfill, groundwater flow in surficial materials is divided into two components: flow that is diverted by the existing groundwater-intercept system and slurry walls, and flow that is not diverted by the existing groundwater-intercept system and slurry walls.

- Some fraction of the flow is diverted by the existing groundwater-intercept system and slurry walls. Existing data indicate that the groundwater-intercept system and slurry walls are most effective in diverting groundwater on the west and south sides of the landfill (DOE 1994a). A groundwater divide between the No Name Gulch drainage and the North Walnut Creek drainage exists approximately 300 feet south of the south groundwater-intercept trench. The presence of this groundwater divide limits the amount of groundwater flow on the south side of the landfill and contributes to the effectiveness of the groundwater diversion structures. The saturated thickness of surficial materials is less on the south side of the landfill than on the north side.
- Some fraction of the flow is not diverted by the existing groundwater-intercept system and slurry walls. This fraction is labeled "groundwater inflow under groundwater intercept system" in Figure 2-8 but could also include flow through the groundwater-intercept system and flow through or under the existing slurry walls. Existing data indicate that the groundwater-intercept system and slurry walls are least effective on the north side of the landfill (DOE 1994a).

Groundwater flowing out of the east boundary of the landfill is funneled to the seep area. Some fraction exits to the surface as seep water and the remainder enters the

pond as groundwater baseflow. Because the bottom of the pond rests directly on weathered bedrock and the dam is keyed into weathered bedrock, the pond and dam interrupt the flow of contaminated groundwater from the landfill and impede its flow down No Name Gulch. Appendix C contains additional information and discussion of groundwater flow modeling and particle tracking.

Seepage occurs between surficial materials and weathered bedrock. Flow could be in either direction but is expected to be mostly downward into the weathered bedrock based on measured water levels in well clusters. The surficial materials and weathered bedrock are combined together as the UHSU because evidence points to a hydraulic connection between the two layers. However, this connection is not evident in all well-cluster locations. For some well clusters (e.g., 70093/70193), the potentiometric surfaces for surficial materials and weathered bedrock are almost identical and move together seasonally. For other well clusters (e.g., 70393/70493 and 4087/B206989), head differences in excess of 20 feet are consistently observed. These head differences most likely indicate that the weathered bedrock in this location is very tight and very little water flows through it. In these locations, flow in surficial materials exists as a "perched" water table over partially saturated weathered bedrock. The water level elevations presented in Figures 2-11 and 2-12 illustrate this phenomena. In all cases, the water level in the weathered-bedrock well is lower than the water level in the surficial-material well. This indicates a consistent downward gradient for groundwater flow.

Groundwater flow in weathered bedrock may be divided into two components. Flow through the matrix and flow through fractures or zones of high hydraulic conductivity.

- Based on the hydraulic conductivity measurements, flow through the weathered bedrock matrix is expected to be approximately three orders of magnitude less than flow in surficial materials. Weathered bedrock in the OU 7 vicinity consists almost exclusively of claystones. The weathered siltstones and sandstones that are present elsewhere at the site are absent at OU 7. The basal Arapahoe or No. 1 sandstone bed, which can be a significant water-bearing unit, is also absent.
- Preferential flow through weathered bedrock fractures or zones of higher hydraulic conductivity is potentially greater than flow through the weathered bedrock matrix. These zones of higher hydraulic conductivity may be potential pathways for the migration of contaminants in weathered bedrock. Higher hydraulic conductivities were not observed at OU 7. They are postulated to explain the apparent migration of certain contaminants in the weathered bedrock, such as nitrate/nitrite in wells B206889 and B206989. Based on all available analytical and hydraulic data, the extent and transport of contamination in the weathered bedrock is limited.

Groundwater flow may occur along an inferred bedrock fault that cuts across the southeastern edge of the landfill (see Figure 2-4) (EG&G 1995a). However, the fault does not offset or fracture the overlying alluvium and potential groundwater flow along the fault would likely be restricted to bedrock. Groundwater traveling along the fault zone would eventually discharge where the fault intersects the hillsides in No Name Gulch east of the landfill, therefore, it is likely that the fault does not serve as a source of inflow to the landfill.

Seepage occurs between the weathered bedrock and the unweathered bedrock. This flow could be in either direction but is expected to be in the downward direction. Water-elevation data from well clusters consistently show water elevations in unweathered bedrock to be lower than water elevations in weathered bedrock. The magnitude of this flow is expected to be very small. The low hydraulic conductivity of the unweathered claystones and siltstones that compose the majority of the unweathered bedrock acts as an effective hydraulic barrier to downward migration of groundwater from the UHSU (EG&G 1995b).

One upgradient monitoring well and three downgradient monitoring wells are required for post-closure groundwater monitoring. The proposed upgradient monitoring location is well 70393, which is due west of the landfill near the headwaters of the former drainage (Figure 2-5). This location will provide information on groundwater quality upgradient of the landfill. The proposed downgradient monitoring locations are 4087, 52894, and 53194, which are downgradient of the landfill in the No Name Gulch drainage and are beyond the area where groundwater flow in surficial materials is interrupted by the dam (Figure 2-5). These locations will ensure that PCOCs are detected if they migrate away from the source and will provide information regarding improvement or degradation of groundwater quality. All proposed wells are alluvial wells.

The three downgradient weathered bedrock wells (B206789, B206889, and B206989) were considered for post-closure monitoring but were rejected for several reasons. Location B206789 falls under the proposed footprint of the landfill cap. Well B206989 does not exhibit a strong connection with the surficial materials as shown in the well hydrograph in Figure 2-13. The difference in potentiometric surfaces between surficial materials and weathered bedrock exceeds 20 feet at well cluster 4087/B206989. Both wells B206889 and B206989 consistently exhibit water levels 12 to 15 feet below the top of bedrock elevation, indicating only partial saturation of weathered bedrock and a "perched" water table condition for surficial materials. Neither well produces enough water for a full suite of chemical analyses. For most historical sampling events, the wells yielded only enough groundwater for a VOC sample (40 milliliters).

2 3 4 2 Groundwater Flow in the LHSU

The LHSU at OU 7 is composed of individual siltstones and sandstones separated by fairly thick confining layers (aquitards) of claystone. Flow rates are comparatively low in all of these lithologic units. Fracturing is much less extensive in unweathered bedrock than in the weathered bedrock. LHSU wells at OU 7 are screened in clayey siltstones to silty fine-grained sandstones. Calcite occasionally occurs as a pore-filling cement. Sandstone lenses in the unweathered bedrock are thin and not laterally continuous (EG&G 1992a, EG&G 1995a), and therefore, are not a major contributor to groundwater flow.

Hydraulic conductivities in these siltstones and sandstones are very low. A sitewide evaluation of hydraulic conductivities of LHSU claystones, siltstones, and sandstones show the geometric means to be within one order of magnitude (2.48×10^{-7} cm/sec, 1.59×10^{-7} cm/sec, and 5.77×10^{-7} cm/sec, respectively). These values indicate that flow rates in the LHSU are only marginally impacted by changes in lithology. Measured hydraulic conductivities at OU 7 are similar to these sitewide values with a geometric mean of 6.4×10^{-7} cm/sec (see Appendix B and Figure 2-10). Flow in the unweathered bedrock is expected to be so small as to be negligible. Contaminant transport in the unweathered bedrock is controlled primarily by diffusion because of the low linear groundwater velocities within the unit (EG&G 1995b). For these reasons, contaminant transport in the LHSU is expected to be negligible and is eliminated from further consideration.

2 3 5 Water Balance for the Landfill

As part of the surface-water hydrology investigations for the IM/IRA, a water balance was performed for the landfill mass using MODFLOW (McDonald and Harbaugh 1988) model outputs for the no-action alternative. Input parameters, modeling runs, results, and a discussion of the results are included in Appendix C. The model was calibrated using site-specific data. Inflows that contribute to leachate generation include recharge by infiltration/percolation of precipitation after evapotranspiration, horizontal groundwater flow from the alluvium under or through the existing groundwater intercept system (primarily on the north side) and under or through the north slurry wing wall, and vertical groundwater flow upward from the weathered bedrock beneath the landfill. Outflow is primarily horizontal flow at the seep.

Conclusions from water-balance calculations indicate that approximately 60 percent of the inflow is groundwater from the alluvium and 40 percent is recharge by infiltration of precipitation (the potential error in water balance calculations is approximately 5 percent). Most of the groundwater inflow (90 percent) occurs on the north side of the landfill. Contributions from the west side (6 percent) and the south side (7 percent) are

relatively insignificant. The water balance shows that both a cap and a slurry wall on the north side of the landfill would significantly reduce additional leachate generation. The water balance for the landfill mass is presented in Appendix C.

2.4 Ecology

The buffer zone surrounding the industrial area at Rocky Flats generally supports a wide variety of native plant communities and wildlife. However, the areas in and around OU 7 have been subject to extensive physical disturbances associated with heavy equipment used for landfill operations and construction of the East Landfill Pond and groundwater-intercept system. Ecological data used to characterize OU 7 were compiled from threatened and endangered species evaluations (ASI 1991), data from the Phase I RFI/RI field investigation (DOE 1994a), and information from the sitewide conceptual model (DOE 1995b). Additional ecological information is presented in the screening-level ecological risk assessment in Appendix D.

2.4.1 Vegetation

Specific plant communities present within OU 7 include mesic mixed grassland, disturbed, bare ground, short marsh, wet meadow, and wetlands (Figure 2-14).

Mesic mixed grassland is the most prevalent native habitat type at OU 7. This diverse plant community occurs on broad flat uplands, valley floors, and hillsides. Differences in slope, aspect, soil type, disturbance, and land-use history are reflected in differences in dominance of the various grasses and forbs characterizing the mesic grassland. Species richness was sampled along 2 meter by 50 meter belt transects within the mesic mixed grassland (DOE 1994a). Of the 106 species identified, 34 were graminoids, 63 forbs, 5 shrubs, and 4 cacti. Of these, 68 percent were native perennial species, suggesting a possible trend toward a native grassland climax community. Dominant grasses were western wheatgrass, Canada bluegrass, prairie junegrass, and big bluestem. Kentucky bluegrass, little bluestem, crested wheatgrass, sand dropseed, blue grama, and needle-and-thread were also present. The most dominant forbs were diffuse knapweed, Louisiana sage, and Canada thistle. Secondary forbs present included aster, slimflower scurfpea, and klamath weed. Wild rose was the most commonly encountered shrub, and prickly pear the most common cactus encountered along transects within this habitat type.

A belt transect sampled within the disturbed community contained 27 plant species: 7 grasses, 1 sedge, and 19 forbs (DOE 1994a). Native species constituted 70 percent of the community, including all of the dominant grasses such as big bluestem, blue grama, Canada bluegrass, and mountain muhly. Narrow-leaf sedge was also common. The dominant forb was diffuse knapweed, an introduced and aggressive weed that infests disturbed sites such as roadsides and waste areas. Other forbs present included

Louisiana sage, hairy gold-ester, blazing star, western ragweed, klamath weed, and fringed sage. There were no shrubs present although fringed sage is sometimes considered a subshrub, because it arises from a wood crown.

A large section of OU 7 is bare ground due to continuous earth moving at the landfill. Plants have little opportunity to germinate, grow, or establish in bare areas. Most of the original topsoil has either been lost through wind and water erosion or buried in the landfill.

Tall and short marsh occur in the area around the East Landfill Pond. Tall marsh occurs at the pond margins and is comprised of a near monoculture of broad-leaved cattail, which probably impacts establishment and growth of other hydrophytic plants. The static water level, before the pond was subject to water transfers, probably promoted the persistence of the cattails. The short marsh type occurs in the sprayed areas north and south of the pond where intermittent spray operations caused more variable hydrologic conditions. The short marsh area is dominated by Baltic rush, which prefers mesic to hydric conditions but will tolerate drier conditions. Disturbed areas around the pond contain weedy species such as Canada thistle and western ragweed (DOE 1994a).

Riparian areas downgradient of the East Landfill Pond are poorly developed and lack extensive woody vegetation. Relatively well-developed riparian areas of North Walnut Creek lie approximately one-half mile to the south (DOE 1995b).

2.4.2 Wildlife

Wildlife within OU 7 include large and small mammals, birds, reptiles, amphibians, and aquatic macroinvertebrates.

The most abundant large mammal is the mule deer. White-tailed deer have also been infrequently observed. Large carnivores present at Rocky Flats are coyotes, red foxes, gray foxes, striped skunks, long-tailed weasels, badgers, bobcats, and raccoons. Eastern cottontails and white-tailed jack rabbits are also present. Small mammals include harvest mice, deer mice, meadow voles, thirteen-lined ground squirrels, hispid pocket mice, silky pocket mice, pocket gopher, house mouse, Mexican woodrats, plains and western harvest mice, prairie voles, and both western and meadow jumping mice (DOE 1980, DOE 1993b).

Common grassland birds at Rocky Flats include western meadowlarks, horned larks, vesper sparrows, grasshopper sparrows, western kingbirds, and eastern kingbirds. Marshlands support song sparrows, common yellowthroats, red-winged blackbirds, common snipe, and sora rails. Common birds of prey include American kestrels, northern harriers, red-tailed hawks, Swainson's hawks, great horned owls, and long-

eared owls. Occasionally, golden eagles, prairie falcons, rough-legged hawks, and short-eared owls are observed. Bald eagles are noted visitors during the winter. Open water areas attract water birds such as mallards, gadwall, green-winged teal, pied-billed grebes, spotted sandpipers, killdeer, great blue herons, black-crowned night-herons, and double-crested cormorants (DOE 1994a).

The Rocky Flats site support several species of reptiles and amphibians. Snake species include the bullsnake, yellow-bellied racer, western terrestrial gartersnake, and prairie rattlesnake. Western painted turtles are also present. Amphibian species include plains leopard frogs, Woodhouse's toads, northern chorus frogs, and tiger salamanders.

The East Landfill Pond supports no fish and only a depauperate benthic macroinvertebrate community (DOE 1994a).

2.4.3 Sensitive Habitats and Endangered Species

Wetlands have been designated along the shoreline of the East Landfill Pond by the US Army Corps of Engineers (Figure 2-15) (COE 1994). Historically constant water levels in the pond have resulted in a well-established, vegetated littoral zone at the north, south, and west pond margins. Cattails are the dominant emergent vegetation in these areas, and the area is used by common wetland wildlife species.

The East Landfill Pond includes approximately 3 percent of the open water habitat and 6 percent of the available shoreline habitat at RFETS, the adjacent wetland represents approximately 1.6 percent of the total (COE 1994). Since the pond was constructed only about 20 years ago, it is probably not a historically important component of the local ecosystem. The importance of the East Landfill Pond to aquatic life at RFETS appears to be minimal. The pond apparently does not contain fish or crayfish populations, if it does, the populations are very small. Without a complex aquatic food web that includes upper-level aquatic consumers, the pond is a limited resource for aquatic-feeding wildlife. Because the pond lacks predaceous fish such as bass, it may be a resource for breeding amphibians such as tiger salamanders, chorus frogs, and bullfrogs (Appendix D).

The pond area has been identified as potential habitat for Preble's meadow jumping mouse (Figure 2-15) (DOE 1995b). The Preble's meadow jumping mouse has been petitioned for listing as a threatened or endangered species pursuant to the Endangered Species Act. The Preble's meadow jumping mouse currently receives protection as a non-game species under the Colorado Non-game, Endangered, or Threatened Species Conservation Act. The Preble's meadow jumping mouse is a subspecies of the meadow jumping mouse and, therefore, receives protection under state law.

Three federally listed endangered wildlife species potentially occur at Rocky Flats the black-footed ferret, peregrine falcon, and bald eagle (ASI 1991) Potential habitat for several Colorado "Category 2" wildlife species occurs at Rocky Flats These are the ferruginous hawk, Preble's meadow jumping mouse, white-faced ibis, mountain plover, long-billed curfew, and swift fox (ASI 1991) Small size and lack of an appropriate prey base precludes OU 7 as an important habitat for these federally listed or Category 2 species (DOE 1994a) Four plant species potentially present at Rocky Flats include one federally-listed threatened species, Ute lady's tresses, one Category 2 species, Colorado butterfly plant, and two species of concern in Colorado, forktip three-awn and toothcup None have been found at Rocky Flats (ASI 1991)

2.5 Nature and Extent of Contamination

The remedial investigation/feasibility study (RI/FS) RCRA facility investigation corrective measures study (RFI/CMS) process for OU 7 was streamlined under the presumptive remedy framework Characterization of the contents of the landfill (waste material) are not necessary or appropriate for selecting a response action (EPA 1993a) Historical information and results from limited characterization efforts are presented in Section 2.1 for the Present Landfill, Inactive Hazardous Waste Storage Area, and the asbestos disposal areas Limited characterization of landfill gas and leachate was performed during the Phase I RFI/RI and results are presented below Sampling efforts for the Phase I and Phase II were focused on characterizing areas where contaminant migration was suspected such as surface water and sediment in the East Landfill Pond, surface soils in spray evaporation areas, subsurface geologic materials downgradient of the landfill, and groundwater downgradient of the landfill The nature and extent of contamination in these media are presented below

2.5.1 Methodology for Background Comparisons and PCOC Identification

Site-to-background comparisons were performed using statistical tests recommended by Gilbert (EG&G 1994b) Statistical tests include the Gehan test, slippage test, quantile test, t-test, and the hot measurement test The hot measurement test is a comparison of the maximum detection to the upper tolerance limit of the 99th percentile at the 99-percent confidence level ($UTL_{99/99}$) for background samples Results were presented for all media in the OU 7 Final Work Plan (DOE 1994a) Data from the sitewide background geochemical characterization report (EG&G 1993c) were used for background samples of sediment, groundwater, seep water, and surface water Data from soil samples collected in the Rock Creek drainage (DOE 1993b) were used for background samples of surface soils Metals, radionuclides, and indicator parameters having concentrations elevated relative to background concentrations, as indicated by any one of the inferential statistical tests or the hot-measurement test, were

identified as PCOCs. Organic compounds were considered PCOCs if detected in samples from OU 7.

For this report, site data were aggregated in populations that reflect potential collection or treatment alternatives. The following populations of data were evaluated: landfill gas, leachate at the seep, surface water in the East Landfill Pond, sediment in the pond, surface soils in the vicinity of spray evaporation areas, subsurface geologic materials (colluvium) downgradient of the landfill, subsurface geologic materials (weathered bedrock) downgradient of the landfill, groundwater in the vicinity of the East Landfill Pond upgradient of the dam, and groundwater downgradient of the dam. Groundwater data were separated into two populations to determine the optimum location for a potential collection system.

Specific data sets used for each medium include the following:

- Landfill gas - 163 chemical-concentration measurements at 33 locations using field instruments that provide screening-level data (i.e., EPA Level II), one sampling event from Phase I RFI/RI.
- Landfill gas - in situ soil-gas sampling, 67 samples collected at 33 locations, one sampling event from Phase I RFI/RI.
- Leachate at the seep (SW097) - monthly data (1990-1991), four months from Phase I RFI/RI (1992-1993).
- Surface water in the East Landfill Pond (SW098) - monthly data (1990-1991), four months from Phase I RFI/RI (1992-1993).
- Sediments in the East Landfill Pond - three samples, one sampling event from Phase I RFI/RI (1993).
- Surface soils in the vicinity of spray evaporation areas - 133 samples from 0-2 inches, 67 samples from 0-10 inches, one event from Phase I RFI/RI (1993), 12 samples from 0-2 inches, 4 samples from 0-10 inches, one event from Phase II RFI/RI (1994).
- Subsurface geologic materials downgradient of the landfill - 21 samples from 2 boreholes (70993 and 71093), 7 from Quaternary colluvium and 14 from weathered bedrock, one event from Phase I RFI/RI (1993).
- Groundwater downgradient of the source area in the vicinity of the pond and downgradient of the dam - quarterly data (1990-1994), four months from Phase I RFI/RI wells (1992-1993), one month from Phase II RFI/RI wells (1994).

The nature and extent of contamination for these media is detailed below. Landfill gas data were not evaluated statistically. Environmental media characterized by other data sets were not investigated for this report because these media are upgradient or within the source. These data sets include surface soils in IHSS 114 and IHSS 203, subsurface geologic materials upgradient of the landfill, surface water discharge from the north and south groundwater intercepts, groundwater upgradient of the landfill, and groundwater within the landfill. Information on contaminant distribution in these media can be found in the OU 7 Final Work Plan (DOE 1994a).

2.5.2 Landfill Gas

The volume of gas present within the landfill was determined by calculating the volume of void space in unsaturated material within the landfill mass assuming an estimated porosity of 30 percent (EPA 1991a). The volume of material comprising the unsaturated zone is approximately 320,000 cubic yards (cy) based on the areal extent of the landfill and an estimated average unsaturated zone thickness of approximately 11 feet. The volume of landfill gas occupying the pore space of the unsaturated material is calculated as approximately 96,000 cy. However, the estimated volume is expected to vary temporally as a result of fluctuations in the potentiometric surface in response to precipitation events and barometric pressure (DOE 1994a).

Gas flow through landfill waste and soils occurs in response to pressure gradients (i.e., advective flow), concentration gradients (i.e., diffusive flow), compaction and settling of wastes, barometric pressure changes, and displacement due to potentiometric surface fluctuations. Advection of landfill gas is typically the predominant transport mechanism (EPA 1991a). Off-gassing pressures up to 0.44 pounds per square inch (lbs/in²) were measured during the Phase I RFI/RI (DOE 1994a). Gas pressures exceeding approximately 0.05 lbs/in² indicate an advective, pressure driven system (Emcon Associates 1982). Gas flow rates ranging from 1 to 35 feet per minute (ft/min) and averaging 11 ft/min were measured during the Phase II RFI/RI.

The composition of landfill-generated gases was evaluated on the basis of screening-level data on total combustible gases, methane, and carbon dioxide. The composition of landfill gas at OU 7 is 45 to 70 percent methane and 20 to 40 percent carbon dioxide, indicating anaerobic conditions (DOE 1994a). Concentrations of methane and carbon dioxide are highest in the eastern portion of the landfill where wastes are thickest and most recently deposited. In general, landfill gases appear to be contained within the existing intercept system. Concentrations of methane and carbon dioxide are relatively low, as expected, in the vicinity of the gas-venting wells. Gas concentration maps and cross sections are included in the OU 7 Final Work Plan (Figures 4-4 through 4-15, DOE 1994a).

Concentrations of non-methane organic compounds (NMOCs) were determined by subtracting methane concentrations from the concentrations of total combustible gases. As a result, the reported concentrations of NMOCs may include minor amounts of inorganic gases such as hydrogen sulfide. Concentrations of NMOCs range from 0 to 152,000 mg/L and average 30,000 mg/L (DOE 1994a). Results of the methane survey are presented in Table 2-2. Sampling locations are shown in Figure 2-5.

In situ soil-gas sampling was performed to characterize hazardous air pollutants (HAPs) in the unsaturated zone of the landfill. Concentrations were reported as mg/L but no corresponding emission rates for generated gases were reported. HAPs detected at the landfill include 1,2-dichloroethene, 1,1,1-trichloroethane, trichloroethene, methylene chloride, acetone, 2-butanone, toluene, xylene, and hydrogen sulfide. Results of soil-gas sampling are presented in Table 2-3. Sampling locations are shown in Figure 2-5.

2.5.3 Landfill Leachate at the Seep

The composition of landfill-generated leachate was evaluated on the basis of screening-level data collected during the Phase I RFI/RI and surface-water monitoring samples collected monthly during the Phase I RFI/RI and the 1990-1991 surface-water monitoring program. Screening-level data were collected from 16 locations, 26 samples were collected (Figure 2-5). Methane concentrations from screening-level data ranged from 0.0003 to 31.4 mg/L and typically approached the solubility limit of 35 mg/L at 17 degrees Celsius (Merck Index 1989). Methane concentrations at OU 7 are consistent with methane concentrations of 25 mg/L observed at other landfills (Beadecker and Back 1979).

Surface-water samples are collected from the seep at the base of the east face of the landfill (SW097, Figure 2-16). Analytes detected in leachate at concentrations that exceeded background concentrations include metals, radionuclides, indicator parameters, VOCs, and semivolatile organic compounds (SVOCs). Concentrations, detection limits, and detection frequencies are presented in Table 2-4. Additional information is presented in the OU 7 Final Work Plan (DOE 1994a).

Professional judgment was used to eliminate certain analytes from the PCOC list (Table 2-4). Two rationales were used for the elimination of analytes: (1) the analytes calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients (EPA 1989a), and (2) other analytes were eliminated from consideration as PCOCs because of infrequent detection, detection in method blanks, or detection in background samples. Alpha-BHC was eliminated as a PCOC because it was detected only once, the result was reported as zero, and the result was "T" qualified, which indicates that there was interference and the result is an estimated value. Carbon

disulfide, tetrachloroethene, and vinyl acetate were eliminated as PCOCs because they were infrequently detected, suggesting that the results are outliers and are not representative of the true population. Methylene chloride was eliminated as a PCOC for two reasons: (1) many of the detections including the maximum detection are 1990 data which were never validated and are "B" qualified (detected in laboratory blanks) and (2) methylene chloride is a common laboratory contaminant which was often detected in background groundwater samples. Methylene chloride was detected in 26 of 100 samples, or 26 percent, in the background data set. The maximum detection in background was 31 µg/L. The UTL_{99/99} for the background data set is 21 µg/L.

After using professional judgment, the following analytes are PCOCs for leachate from the seep:

- Metals - antimony, barium, iron, lithium, manganese, strontium, and zinc,
- Radionuclides - gross beta, strontium-89,90, tritium,
- SVOCs - 2,4-dimethylphenol, 2-methylnaphthalene, 4-methylphenol, acenaphthene, bis(2-ethylhexyl)phthalate, dibenzofuran, diethyl phthalate, fluorene, naphthalene, and phenanthrene,
- VOCs - 1,1-dichloroethane, 1,2-dichloroethene, 2-butanone, 2-hexanone, 4-methyl-2-pentanone, acetone, benzene, chloroethane, chloromethane, ethylbenzene, o-xylene, toluene, total xylene, trichloroethene, and vinyl chloride,
- Indicator parameters - nitrite

2.5.4 Surface Water in the East Landfill Pond

The composition of pond water was evaluated on the basis of surface-water monitoring samples collected monthly during the Phase I RFI/RI and the 1990-1991 surface-water monitoring program. Surface-water samples were collected from station SW098, located in the central east section of the pond adjacent to the dam (Figure 2-16). Analytes that were detected at concentrations above background concentrations include metals, radionuclides, VOCs, and SVOCs. None of the VOCs nor SVOCs were detected frequently. Concentrations, detection limits, and detection frequencies are presented in Table 2-5. Only analytes that were detected are included in the table. Additional information is presented in the OU 7 Final Work Plan (DOE 1994a).

Professional judgment was used to eliminate certain analytes from the PCOC list (Table 2-5). Two rationales were used for the elimination of analytes: (1) the analytes calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients (EPA 1989a), and (2) other analytes were eliminated from consideration as PCOCs because of infrequent detection, detection in method blanks, or detection in

background samples Acetone, methylene chloride, and vinyl acetate were eliminated because they were infrequently detected, suggesting that the results are outliers and are not representative of the true population Acetone and methylene chloride were also detected in laboratory blanks ("B" qualified)

After using professional judgment, the following analytes are PCOCs for surface water in the East Landfill Pond

- Metals - arsenic, lithium, manganese, molybdenum, nickel, strontium, thallium, tin
- Radionuclides - americium-241, gross alpha, gross beta, strontium-89,90, tritium, uranium-235, and uranium-238
- SVOCs - bis(2-ethylhexyl)phthalate and di-n-butyl phthalate

2 5 5 Sediments in the East Landfill Pond

Sediment samples were collected at three locations in the pond to assess the impact of nearby point sources of contamination (seep, north groundwater intercept outfall, and south groundwater intercept system outfall) and nonpoint runoff from the landfill and were analyzed for VOCs, SVOCs, radionuclides, metals, and inorganics (see Figure 2-16) None of the metals or radionuclides exceeded background UTL 99/99 values Three VOCs and several SVOCs were detected in pond sediments All SVOC results are estimated values below the quantitation limit ("J" qualified) Concentrations, detection limits, detection frequencies, and qualifiers are presented in Table 2-6 Only analytes that were detected are included in the table Additional information is presented in the OU 7 Final Work Plan (DOE 1994a)

Professional judgment was used to eliminate certain analytes from the PCOC list (Table 2-6) The analytes calcium, magnesium, potassium, and sodium were eliminated as PCOCs because they are essential nutrients (EPA 1989a) Acetone was detected in the laboratory blank ("B" qualified) for the maximum detection, however, because it was detected in more than 50 percent of the samples, acetone was not eliminated from the PCOC list

After using professional judgment, the following analytes are PCOCs for sediments in the East Landfill Pond

- SVOCs - acenaphthene, anthracene, benzo(a) anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, benzoic acid, bis(2-chloroisopropyl)ethene, bis(2-ethylhexyl)phthalate, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene
- VOCs - 2-butanone, acetone, and toluene

2 5 6 Surface Soils in Spray Evaporation Areas

Surface-soil samples were collected on a grid from the landfill eastward across the spray evaporation areas and surrounding slopes and downwind below the dam (Figure 2-17). Soil samples were collected at 133 locations from the 0- to 2-inch soil horizon and 67 locations from the 0- to 10-inch soil horizon during the Phase I RFI/RI (DOE 1994a). Soil samples were collected at 12 locations from the 0- to 2-inch soil horizon and 4 locations from the 0- to 10-inch soil horizon during the Phase II RFI/RI. All samples were analyzed for metals and radionuclides. Concentrations, detection limits, detection frequencies, and qualifiers are presented in Table 2-7. Only analytes that were detected are included in the table. Additional information is presented in the OU 7 Final Work Plan (DOE 1994a).

Arsenic was detected in all samples and was frequently detected above background. The maximum concentration of arsenic is 15.7 mg/kg at a location southwest of the South Area Spray Field (SS702293, Figure 2-17). The maximum activity of americium-241 is 1.076 picocuries per gram (pCi/g) at a location on the hillslope south of the pond (SS703793, Figure 2-13). This area was regraded during routine maintenance at the landfill in September 1993 and falls under the proposed footprint of the landfill cap. The maximum activity of radium-226 is 1.8 pCi/g at a location downwind of the spray evaporation areas below the dam (SS711193, Figure 2-17). Radium-226 was not detected at this activity in confirmation samples collected during the Phase II field investigation.

Professional judgment was used to eliminate calcium, magnesium, potassium, and sodium as PCOCs because they are essential nutrients (EPA 1989a).

After using professional judgment, the following analytes are PCOCs for surface soils in the vicinity of the East Landfill Pond:

- Metals - antimony, arsenic, barium, beryllium, cobalt, copper, lead, mercury, selenium, silver, strontium, thallium, vanadium, and zinc
- Radionuclides - americium-241, plutonium-239,240, and radium-226
- Indicator parameters - nitrate/nitrite and total organic carbon (TOC)

2 5 7 Subsurface Geologic Materials Downgradient of the Landfill

Subsurface geologic materials were sampled in two boreholes to characterize potential leachate-contaminated materials downgradient of the landfill (Figure 2-18). Samples were collected at 2-foot increments in colluvium and 4-foot increments in bedrock. A total of 21 samples were collected, 7 from colluvium and 14 from bedrock. All samples were analyzed for VOCs, SVOCs, PCBs, metals, radionuclides, and indicator

parameters (TOC, nitrate, and sulfide) Analytes that were detected at concentrations or activities above background concentrations or activities include metals, radionuclides, SVOCs, VOCs, and indicator parameters in colluvium, and metals and VOCs in weathered bedrock Concentrations, detection limits, and detection frequencies are presented in Table 2-8 Only analytes that were detected are included in the table Additional information is presented in the OU 7 Final Work Plan (DOE 1994a)

Professional judgment was used to eliminate calcium, magnesium, potassium, and sodium as PCOCs in colluvium and weathered bedrock because they are essential nutrients (EPA 1989a) All SVOC results are estimated values below the quantitation limit ("J" qualified) 1,1,1-trichloroethane was eliminated as a PCOC in weathered bedrock because it was detected only once, which suggests that the detection is an outlier and is not representative of the population, and the result is an estimated value ("J" qualified)

After using professional judgment, the following analytes are PCOCs for surface geologic material in colluvium downgradient of the landfill

- Metals - barium
- Radionuclides - cesium-137
- SVOCs - chrysene, fluoranthene, phenanthrene, and pyrene
- VOCs - 4-methyl-2-pentanone, toluene, and total xylenes
- Water quality parameters - nitrate/nitrite

After using professional judgment, the following analytes are PCOCs for surface geologic material in weathered bedrock downgradient of the landfill

- Metals - arsenic, barium, cobalt, lead, strontium, and zinc
- VOCs - toluene

2 5 8 Groundwater Downgradient of the Landfill

Groundwater downgradient of the landfill is separated into two populations for data evaluation to assist in delineating areas where groundwater has been impacted by migration of landfill leachate (Figure 2-18) These populations are groundwater in the vicinity of the East Landfill Pond upgradient of the dam, and groundwater downgradient of the dam Nine existing wells are screened across surficial material or weathered bedrock, three near the East Landfill Pond, and six downgradient of the dam Three wells are screened across unweathered bedrock sandstones or siltstones, one near the pond and two downgradient of the dam Groundwater samples have been collected from the older wells since 1986 or 1989 and from the new wells since December 1994 Data from 1990 to 1995 were used in this report Table 2-9 lists the well locations,

geologic formation well is screened across, hydrostratigraphic unit, date well was installed, and population for data aggregation (wells in the vicinity of the East Landfill Pond versus wells downgradient of the dam) Figure 2-18 shows the well locations and outlines the populations used for data aggregation

Background comparisons for inorganic analytes and radionuclides were performed on the two populations of UHSU groundwater to determine PCOCs using the Gilbert methodology (EG&G 1994b) Analytes that fail any of the tests are identified as PCOCs The results of the statistical tests for wells in the vicinity of the East Landfill Pond and downgradient of the dam are presented in Tables 2-10 and 2-11, respectively In addition to the inorganic analytes and radionuclides that fail the statistical tests, all VOCs and SVOCs detected in groundwater are considered PCOCs unless eliminated by professional judgment

Professional judgment was used to eliminate certain analytes from the PCOC list Two major rationales were used for the elimination of analytes (1) the analytes calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients (EPA 1989a), and (2) other analytes were eliminated from consideration as PCOCs because of infrequent detection, detection in method blanks, or detection in background samples

For the groundwater in vicinity of the East Landfill Pond (Table 2-10), 1,1-dichloroethane, acetone, benzene, chloroethane, ethylbenzene, toluene, and total xylenes were eliminated because infrequent detection suggests that the detection(s) are outliers Methylene chloride was eliminated for two reasons (1) many of the detections are 1990 data which were never validated and are "B" qualified (detected in laboratory blanks) and (2) methylene chloride is a common laboratory contaminant which was often detected in background groundwater samples For the data set used for background comparisons, methylene chloride was detected in 43 of 298 samples, or 14 percent of samples The maximum detection in background was 42 $\mu\text{g/L}$ The $\text{UTL}_{99/99}$ for the background data set is 16 $\mu\text{g/L}$ For the groundwater in vicinity of the East Landfill Pond, methylene chloride was detected in 7 of 51 samples, or 14 percent of samples The maximum detection in background was 8 $\mu\text{g/L}$ The $\text{UTL}_{99/99}$ is 6.0 $\mu\text{g/L}$

For the groundwater downgradient of the dam (Table 2-11), antimony, benzene, and toluene were eliminated because infrequent detection suggests that the detection(s) are outliers Methylene chloride was eliminated for the same reasons stated above For the groundwater downgradient of the dam, methylene chloride was detected in 10 of 52 samples, or 19 percent of samples The maximum detection in background was 12 $\mu\text{g/L}$ The $\text{UTL}_{99/99}$ is 8.9 $\mu\text{g/L}$

After the use of professional judgment, the following PCOCs remain for the UHSU groundwater in the vicinity of the East Landfill Pond

- Metals - antimony, lithium, selenium, silver, and strontium
- Radionuclides - uranium-238
- SVOCs - bis(2-ethylhexyl)phthalate
- VOCs - carbon tetrachloride, tetrachloroethene, and trichloroethene (It should be noted that these volatile organics would have been eliminated because of infrequent detection if not for the fact that they were detected in the last sample analyzed)
- Indicator parameters - bicarbonate as CaCO_3 , chloride, nitrate/nitrite, orthophosphate, sulfate, and total dissolved solids

After the use of professional judgment, the following PCOCs remain for the UHSU groundwater downgradient of the dam

- Metals - lithium and strontium
- Radionuclides - strontium-89,90
- Indicator parameters - bicarbonate as CaCO_3 , carbonate as CaCO_3 , chloride, fluoride, nitrate/nitrite, orthophosphate, sulfate, and total dissolved solids

Background comparisons for inorganic analytes and radionuclides were performed on one population of LHSU groundwater to determine PCOCs. The results of the statistical tests for LHSU wells downgradient of the landfill are presented in Table 2-12. Again, some analytes were eliminated by professional judgment. Calcium, magnesium, potassium, and sodium were eliminated as PCOCs because they are essential nutrients (EPA 1989a). Acetone, chlorobenzene, toluene, and total xylenes were eliminated as PCOCs because infrequent detection suggests that the detection(s) are outliers. Methylene chloride was eliminated for the reasons stated above. After using professional judgment, the PCOCs remaining for LHSU downgradient of the landfill are carbonate and orthophosphate. Given the hydrology of the unweathered bedrock (Section 2.3.4) and the nature of these analytes, groundwater in the LHSU downgradient of the landfill will receive no further consideration.

Table 2-1
Geotechnical Classification Test Results for Soil Samples

Sample Number	Borehole Number	Sample Depth (feet)	Description and USCS Soil Classification	Natural Moisture Content (ASTM D2216), %	Grain Size Distribution (ASTM D422)	Atterberg Limits (ASTM D4318)	Specific Gravity (ASTM D854)
BH70405ST	53494	0 to 12.6	Alluvium, Clayey Sand (SC)	5.7	Gravel 35% Sand 39% Silt 10% Clay 16%	PI = 14%	2.67
BH70403ST	53594	0 to 1.8	Alluvium Clayey Sand (SC)	8.0	Gravel 25% Sand 40% Silt 17% Clay 18%	PI = 17%	2.64
BH70401ST	53694	0 to 2	Colluvium, Fat Clay (CH)	13.9	Gravel 0% Sand 8% Silt 30% Clay 62%	PI = 41%	2.52
BH70407ST	52794	0 to 2	Colluvium, Fat Clay (CH)	21.2	Gravel 22% Sand 10% Silt 23% Clay 45%	PI = 44%	2.65

Definitions

ASTM American Society of Testing and Materials

USCS Unified Soil Classification System

PI plasticity index

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Table 2-2
Concentrations of NMOCs, Methane, and Carbon Dioxide in Landfill Gas

Location	Depth (feet)	Total Organic Gases (ppm)	NMOCs (ppm)	Methane (ppm)	Carbon Dioxide (ppm)
CPT00193	NP-REF	NP-REF	NP REF	NP-REF	NP-REF
CPT00293	3 28	330	75	255	NP EQUIP
CPT00393	3 28	510	210	300	NP EQUIP
	8 2	5 000	375	4,625	NP EQUIP
	13 12	≥67,600 ¹	≥0	67,600	54,000
	16 73	95,000	1,260	93,740	NP-EQUIP
CPT00493	3 28	1,900	65	1,835	NP-EQUIP
	8 2	120,000	23,000	97,000	72,000
	13 12	100,000	24,000	76 000	70,000
	18 04	1 200	50	1,150	NP-EQUIP
	22 96	140	26	114	NP-EQUIP
CPT00593	3 28	700	90	610	NP EQUIP
	8 2	150,000	31,000	119,000	6,800
	13 12	270,000	57,000	213,000	111,000
	18 04	640	18	622	NP-EQUIP
	22 96	6,000	2,000	4,000	6,000
CPT00693	3 28	200,000	41 000	159,000	113,000
	8 2	360,000	58,000	302,000	166,000
	13 12	380,000	74,000	306 000	149,000
	18 04	330 000	48,000	282 000	164,000
	22 96	340	6	334	NP-EQUIP
CPT00793	3 28	270,000	45,000	225,000	102,000
	8 2	70,000	29,000	41,000	34,000
	13 12	390,000	73,000	317,000	156,000
	18 04	≥17,000 ²	≥0	17,000	16,000
	22 14	9,600	220	9,380	NP-EQUIP
CPT00893	3 28	65,000	27,000	38,000	16,000
	8 2	3,700	49	3,651	5,000
	13 12	180,000	37,000	143,000	60,000
	18 04	100,000	26,000	74,000	37,000
	22 96	68	6	62	NP-EQUIP
CPT00993	3 28	360,000	85,000	275 000	191,000
	8 2	≥25,000 ²	≥0	25,000	22 000
	13 12	140,000	41,000	99,000	64,000

Location	Depth (feet)	Total Organic Gases (ppm)	NMOCs (ppm)	Methane (ppm)	Carbon Dioxide (ppm)
CPT01093	18 04	260,000	59,000	201,000	108,000
	3 28	520,000	81,000	439,000	218,000
	8 2	380,000	35,000	345,000	219,000
	13 12	65,000	27,000	38,000	29,000
	18 04	200,000	33,000	167,000	88,000
	22 96	120,000	24,000	96,000	65,000
	27 88	110	0	110	NP-EQUIP
CPT01193	3 28	560,000	70,000	490,000	173,000
	8 2	180,000	41,000	139,000	54,000
	13 12	570,000	101,000	469,000	160,000
	18 04	200,000	46,000	154,000	55,000
CPT01293	3 28	54	2	52	NP-EQUIP
	8 2	100	0	100	NP EQUIP
	13 12	400,000	32,000	368,000	155,000
	18 04	50	0	50	NP-EQUIP
CPT01393	3 28	510,000	74,000	436,000	173,000
	8 2	480,000	54,000	426,000	181,000
	13 12	520,000	72,000	448,000	188,000
	18 04	880	12	868	NP-EQUIP
	22 96	470,000	75,000	395,000	189,000
	27 88	570	58	512	NP-EQUIP
	32 8	52	0	52	NP-EQUIP
	37 72	540	22	518	NP-EQUIP
CPT01493	3 28	22	0	22	NP-EQUIP
	8 2	520,000	118,000	402,000	133,000
	13 12	480,000	107,000	373,000	160,000
	18 04	540,000	118,000	422,000	161,000
	22 96	440,000	49,000	391,000	168,000
	27 88	510,000	108,000	402,000	175,000
	32 8	450,000	75,000	375,000	190,000
	37 72	470,000	102,000	368,000	170,000
	42 64	200,000	43,000	157,000	62,000
CPT01593	3 28	370	4	366	NP-EQUIP
	8 2	640,000	147,000	493,000	114,000
	13 12	520,000	48,000	472,000	114,000
	18 04	430,000	30,000	400,000	202,000
	22 96	470,000	45,000	425,000	213,000
	27 88	470,000	82,000	388,000	199,000

Location	Depth (feet)	Total Organic Gases (ppm)	NMOCs (ppm)	Methane (ppm)	Carbon Dioxide (ppm)
	32 8	310,000	79,000	231,000	59,000
CPT01693	NP-ACC	NP-ACC	NP ACC	NP-ACC	NP-ACC
CPT01793	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF
CPT01893	3 28	140	24	116	NP-EQUIP
	8 2	250	98	152	NP EQUIP
	13 12	140	0	140	NP-EQUIP
CPT01993	3 28	140,000	35,000	105,000	52,000
	8 2	105	3	102	NP-EQUIP
	13 1	38	0	38	NP-EQUIP
CPT02093	3 28	92	0	92	NP-EQUIP
	8 2	470,000	112,000	358,000	86,000
	13 1	570 000	152,000	418,000	103,000
	18 04	600,000	122 000	478 000	78,000
	22 96	100	0	100	NP-EQUIP
	27 88	590,000	85,000	505,000	132,000
	32 8	120	26	94	NP-EQUIP
CPT02193	NP-DUP	NP-DUP	NP DUP	NP DUP	NP DUP
CPT02293	3 28	360,000	40,000	320,000	135,000
	8 2	480,000	95 000	385,000	165 000
	13 12	370,000	15,000	355,000	169,000
	18 04	230,000	7,000	223,000	125,000
	22 96	430,000	74,000	356,000	149,000
	27 88	470,000	114,000	356,000	145,000
	32 8	440 000	69,000	371,000	160,000
	37 72	490,000	95,000	395,000	128,000
	41	410,000	10,000	400 000	156,000
	42 64	230,000	61,000	169,000	75,000
CPT02393	3 28	2,300	46	2,254	4,000
	8 2	390,000	43,000	347,000	106,000
	13 12	130,000	23,000	107,000	44,000
	18 04	340,000	54,000	286,000	111,000
	22 96	360,000	84,000	276,000	108,000
	27 88	230,000	2,000	228,000	94,000
CPT02493	3 28	280	2	278	NP-EQUIP
	8 2	430,000	76,000	354,000	162,000
	13 12	480,000	67,000	413,000	171,000
	17 71	1 400	80	1,320	NP-EQUIP

Location	Depth (feet)	Total Organic Gases (ppm)	NMOCs (ppm)	Methane (ppm)	Carbon Dioxide (ppm)
CPT02593	3 28	2	0	2	NP-EQUIP
	8 2	140,000	1,000	139,000	76,000
	13 12	38	4	34	NP-EQUIP
CPT02693	3 28	$\geq 18,000^2$	≥ 0	18,000	23,000
	8 2	$\geq 9,000^2$	≥ 0	9,000	12 000
	13 12	130 000	26 000	104,000	52,000
	18 04	180,000	62,000	118,000	57 000
	22 96	1,800	12	1,788	4 000
CPT02793	3 28	48	0	48	NP-EQUIP
	5 9	26	2	24	NP-EQUIP
CPT02893	3 28	160,000	27,000	133,000	147,000
	8 2	$\geq 15,000^2$	≥ 0	15,000	25,000
	13 12	1,100	12	1,088	2,000
	18 04	430,000	98,000	332,000	135,000
	22 96	740	6	734	2,000
	27 88	580	8	572	2,000
	32 8	350	2	348	NP-EQUIP
CPT02993	3 28	290	28	262	NP-EQUIP
	8 2	4,200	80	4,180	2,000
	13 12	320 000	66,000	254,000	90,000
	18 04	68	2	66	NP EQUIP
	22 96	38	0	38	NP-EQUIP
CPT03093	3 28	820	76	744	NP EQUIP
	8 2	170,000	56,000	114,000	88,000
	13 12	170,000	40,000	130,000	85,000
	18 04	150,000	45,000	105,000	73,000
	22 96	1,900	83	1,817	NP-EQUIP
	27 88	4,000	120	3,880	NP-EQUIP
	32 8	5,600	60	5,540	NP-EQUIP
CPT03193	3 28	1,000	46	954	NP-EQUIP
	8 2	900	64	836	NP-EQUIP
	13 12	520,000	77,000	443,000	175,000
	18 04	160,000	41,000	119,000	51,000
	22 96	390,000	67,000	323,000	219,000
CPT03293	3 28	1,200	8	1,192	NP-EQUIP
	8 2	5,200	120	5,080	NP EQUIP
	13 12	$\geq 14 000^2$	≥ 0	14,000	10,000
	18 04	350	12	338	NP-EQUIP

Location	Depth (feet)	Total Organic Gases (ppm)	NMOCs (ppm)	Methane (ppm)	Carbon Dioxide (ppm)
CPT03393	3 28	5,600	205	5,395	NP-EQUIP
CPT03493	3 28	167,390	390	167,000	77,000
	8 2	380,000	84,000	296,000	173,000
	13 12	291,000	64 000	227,000	136,000
	18 04	194,000	60,000	134,000	110,000
CPT03593	3 28	55	0	55	NP-EQUIP
	8 2	10,000	0	10,000	10,000
	13 12	250,000	48,000	202 000	150,000
	18 04	120	4	116	NP-EQUIP
	22 47	92	3	89	NP-EQUIP
CPT03693	3 28	18	0	18	NP-EQUIP
	8 2	430,000	70,000	360,000	146,000
	13 12	470,000	51,000	419,000	181,000
	18 04	480,000	61,000	419,000	178,000
	22 96	760	12	748	NP-EQUIP
CPT03793	3 28	5	0	5	NP EQUIP
	8 2	320,000	48,000	272,000	146,000
	13 12	52	0	52	NP-EQUIP
	18 04	110	0	110	NP-EQUIP
	22 96	52	0	52	NP-EQUIP
CPT03893	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF

¹ Exact concentration of total gas not available due to low batteries in the Digiflam analyzer

² Concentration of total gas was between detection limits of the Digiflam analyzer and the GasTech Tank Techtor. The Digiflam analyzer was used to detect concentrations above approximately 10 000 ppm, while the GasTech Tank-Techtor was used to measure concentrations below approximately 10 000 ppm

Definitions

NMOCs non-methane organic compounds

NP-ACC not performed access, methane survey not performed at this location due to safety concerns associated with mobilizing the rig down the hillside to the sampling location located below the steep face of the landfill along the western boundary of the East Landfill Pond

NP DUP not performed-duplication of effort, methane survey not performed at this site because two other locations (CPT01593 and CPT02293) encountered the buried sediments of the West Landfill Pond and landfill gas measurements were obtained at these locations

NP-EQUIP not performed-equipment instruments used were not capable of detecting low concentrations (i.e., <2,000 ppm) of carbon dioxide

NP REF not performed refusal methane survey was not performed at this location due to shallow refusals encountered at this site during the CPT investigation

CPT cone penetration testing

ppm parts per million

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Table 2-3
Concentrations of Hazardous Air Pollutants in Landfill Gas

Location	Depth (feet)	Volatile Organic Compounds ¹ (parts per million)										
		Methane	Methylene Chloride	Acetone	2-Butanone	1,2-DCE	1,1,1-TCA	TCE	Toluene	para, meta Xylene	ortho Xylene	Hydrogen Sulfide
CPT00193	NP-REF	NP-REF	NP-REF	NP REF	NP-REF	NP-REF	NP-REF	NP-REF	NP REF	NP-REF	NP-REF	NP-REF
CPT00293	4 92	6 6	<0 005	7 308	<0 005	1 94	<0 005	<0 005	0 013	0 013	0 018	1 113
	8 2	5 4	<0 005	5 509	0 081	11 387	<0 005	0 005	0 009	0 01	0 015	0 519
CPT00393	4 92	3478 2	<0 005	2 367	0 147	9 337	<0 005	0 007	0 062	0 013	0 005	1 113
CPT00493	14 76	41727 2	472 302	17 643	3 558	46 857	<0 005	0 024	2 768	0 032	0 035	<0 005
	4 92	20814 9	<0 005	0 413	0 81	12 298	<0 005	<0 005	0 034	0 017	0 415	<0 005
	14 17	32835 8	146 25	<0 005	0 505	11 501	<0 005	0 041	0 017	0 008	0 054	<0 005
	18 04	49598 2	625 72	0 26	0 532	80 562	<0 005	0 011	0 023	0 03	0 015	<0 005
CPT00593	4 92	4512 9	<0 005	3 287	0 074	9 678	<0 005	<0 005	0 013	0 013	<0 005	<0 005
CPT00693	18 24	66267 8	1,138 46	0 424	0 33	129 07	24 26	0 03	0 016	0 015	<0 005	<0 005
	4 92	72199 2	1,708 54	13 333	7 851	57 56	<0 005	0 282	0 252	0 632	0 543	78 783
CPT00793	13 94	ND GC	ND-GC	ND GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC
	4 92	3265 0	<0 005	1 39	<0 005	<0 005	<0 005	0 006	0 005	<0 005	0 01	<0 005
CPT00893	10 66	20201 5	<0 005	1 085	0 108	16 283	<0 005	0 005	0 058	0 009	0 015	<0 005
	4 92	27679 4	6 309	3 6	0 355	4 099	<0 005	<0 005	0 009	0 016	0 011	0 223
CPT00993	10 66	56588 4	459 971	4 279	0 732	92 119	<0 005	0 18	0 252	0 891	0 753	<0 005
	4 92	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC
	7 87	83348 1	228 265	14 282	1	74 64	<0 005	0 207	0 315	0 957	0 771	<0 005
	10 66	4239 7	<0 005	4 062	0 561	6 95	<0 005	<0 005	0 007	0 02	0 008	<0 005
CPT01093	4 92	79982 3	3,108 53	24 021	5 02	165 394	<0 005	1 288	2 196	3 887	3 277	<0 005
CPT01193	13 12	69081 4	2,292 40	19 855	7 436	275 107	<0 005	1 11	2 037	3 697	3 211	<0 005
	4 92	74848 2	1,975 75	4 49	0 699	67 638	<0 005	0 017	0 119	0 015	0 017	<0 005
	9 84	84390 3	1,834 72	13 157	7 454	131 404	148 34	0 054	1 261	0 109	0 127	<0 005

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Location	Depth (feet)	Volatile Organic Compounds ¹ (parts per million)										
		Methane	Methylene Chloride	Acetone	2-Butanone	1,2-DCE	1,1,1-TCA	TCE	Toluene	para, meta Xylene	ortho Xylene	Hydrogen Sulfide
CPT01293	4.92	31209.7	<0.005	5.612	0.763	13.664	<0.005	0.92	1.543	3.373	2.802	0.371
	9.84	48916.8	676.191	6.17	2.389	29.037	<0.005	0.662	1.135	1.805	1.335	<0.005
	15.58	23785.1	40.721	5.173	0.518	24.994	<0.005	0.74	1.166	2.18	1.667	0.223
CPT01393	4.92	47712.6	759.639	6.357	1.679	44.295	<0.005	0.874	1.636	4.74	4.404	<0.005
	19.02	84514.5	1,759.30	80.01	21.866	145.296	<0.005	0.641	2.928	2.819	2.43	<0.005
	23.78	75164.8	1,652.63	32.656	26.007	115.064	<0.005	0.504	3.824	2.284	1.899	<0.005
CPT01493	4.92	57335.5	798.352	8.455	0.432	78.455	<0.005	0.09	0.046	0.016	0.01	<0.005
	36.08	27609.7	88.897	0.857	0.271	12.753	<0.005	<0.005	0.006	0.007	<0.005	0.148
	4.92	56003.9	322.61	6.884	1.784	79.253	<0.005	0.24	0.948	1.253	0.945	<0.005
CPT01593	27.88	107694.4	1,497.49	27.359	4.326	59.098	<0.005	0.297	0.805	1.016	0.744	<0.005
	NP-ACC	NP-ACC	NP-ACC	NP-ACC	NP-ACC	NP-ACC	NP-ACC	NP-ACC	NP-ACC	NP-ACC	NP-ACC	NP-ACC
	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF
CPT01893	4.92	10612.1	145.677	4.662	1.299	6.604	<0.005	0.185	0.346	1.064	0.801	0.223
	7.38	143.5	<0.005	2.212	0.389	17.08	<0.005	0.27	0.437	1.159	0.832	0.297
	4.92	27654.5	<0.005	22.17	<0.005	6.035	<0.005	0.008	0.103	<0.005	0.01	0.074
CPT01993	8.2	292.5	<0.005	2.35	0.189	20.382	<0.005	0.073	0.095	0.133	0.115	<0.005
	4.92	73272.7	730.103	7.049	4.002	43.384	<0.005	0.074	0.099	0.094	0.088	<0.005
	27.88	67085.1	751.897	18.16	0.449	679.966	<0.005	0.131	0.005	5.234	<0.005	<0.005
CPT02093	32.8	61.1	<0.005	7.623	<0.005	<0.005	<0.005	0.005	0.126	<0.005	4.83	0.816
	NP-DUP	NP-DUP	NP-DUP	NP-DUP	NP-DUP	NP-DUP	NP-DUP	NP-DUP	NP-DUP	NP-DUP	NP-DUP	NP-DUP
	4.92	63551.1	1,027.19	9.525	3.289	34.047	<0.005	0.258	1.041	1.035	0.768	<0.005
CPT02293	35.26	79584.3	1,924.77	12.155	0.42	43.042	72.89	0.221	0.377	0.962	0.702	<0.005
	4.92	1680.2	<0.005	0.491	0.526	27.556	<0.005	<0.005	0.012	0.081	<0.005	0.519
	18.04	42172.3	405.485	4.868	1.547	30.573	<0.005	0.021	0.26	0.011	0.006	<0.005
CPT02493	4.92	54907.9	802.368	17.529	4.557	38.317	<0.005	0.217	0.346	0.759	0.53	<0.005
	10.66	67023.9	3,437.74	18.718	<0.005	43.669	338.7	0.209	0.502	0.91	0.689	<0.005

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Location	Depth (feet)	Volatile Organic Compounds ¹ (parts per million)											Hydrogen Sulfide
		Methane	Methylene Chloride	Acetone	2-Butanone	1,2-DCE	1,1,1-TCA	TCE	Toluene	para, meta Xylene	ortho Xylene		
CPT02593	4.92	12227.5	<0.005	5.013	0.347	10.362	<0.005	0.156	0.245	0.728	0.525	0.742	
	8.2	61411.3	580.412	7.742	<0.005	24.254	66.86	0.243	0.25	0.005	0.558	<0.005	
CPT02693	4.1	24.4	65.382	0.997	0.052	6.43	2.32	<0.005	0.01	0.006	0.006	0.223	
CPT02793	4.92	946.1	<0.005	4.098	0.168	58.187	<0.005	0.134	0.317	0.673	0.48	0.89	
CPT02893	4.92	52083.5	749.024	10.879	<0.005	67.866	1,303.95	0.181	0.03	0.06	1.103	<0.005	
	22.14	69280.6	3,431.71	23.442	2.947	164.198	<0.005	0.232	0.338	0.919	0.29	<0.005	
CPT02993	4.92	7931.1	52.765	2.853	0.247	14.063	<0.005	0.048	0.067	0.207	0.155	0.074	
	9.84	38382.7	247.191	5.633	0.347	126.28	<0.005	0.038	0.071	0.203	0.177	0.148	
CPT03093	4.92	40.6	<0.005	0.703	<0.005	14.404	<0.005	0.005	0.013	0.011	<0.005	<0.005	
	16.4	57490.5	575.824	0.672	5.809	59.382	<0.005	0.008	0.011	0.011	0.016	0.668	
CPT03193	4.92	9314.8	<0.005	2.44	<0.005	34.331	<0.005	0.151	0.183	0.581	0.461	0.074	
	13.12	83035.6	1,355.25	15.514	5.933	190.96	96.69	0.107	0.686	0.282	0.229	<0.005	
CPT03293	4.92	ND-GC	ND-GC	ND-GC	ND-GC	ND-GC	ND GC	ND-GC	ND-GC	ND-GC	ND-GC	ND GC	
	9.84	56183.0	196.15	0.75	1.262	44.983	<0.005	0.23	0.29	0.778	0.636	0.074	
CPT03393	4.26	46726.0	452.515	0.171	0.142	36.096	<0.005	0.007	0.015	0.007	<0.005	<0.005	
	5.12	56181.5	404.338	0.206	0.211	6.377	<0.005	0.006	0.049	0.007	0.034	<0.005	
CPT03493	4.92	45191.5	157.95	1.143	0.168	24.482	<0.005	0.01	0.012	0.012	0.01	<0.005	
	18.04	47422.4	308.53	1.674	0.129	21.407	<0.005	0.006	0.009	0.007	0.016	0.816	
CPT03593	4.92	53933.0	1,007.12	6.429	0.312	58.415	<0.005	0.03	0.008	0.012	0.017	<0.005	
CPT03693	4.92	69528.6	1,468.47	9.096	3.405	98.724	<0.005	0.069	1.243	0.055	0.053	<0.005	
	18.86	8053.3	<0.005	2.532	0.242	8.597	<0.005	<0.005	0.081	0.021	0.005	<0.005	
CPT03793	4.92	12822.1	<0.005	5.22	0.25	10.818	<0.005	<0.005	0.007	0.014	0.01	<00.005	
	18.86	10665.7	26.096	4.84	0.17	9.11	<0.005	<0.005	0.023	0.014	0.02	0.074	

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Location	Depth (feet)	Volatile Organic Compounds ¹ (parts per million)										
		Methane	Methylene Chloride	Acetone	2-Butanone	1,2-DCE	1,1,1-TCA	TCE	Toluene	para, meta Xylene	ortho Xylene	Hydrogen Sulfide
CPT03893	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF	NP-REF

¹ Volatile organic compounds were analyzed onsite using a field gas chromatogram (GC) equipped with a photoionization detector (PID) and a flame ionization detector (FID)

Definitions

CPT cone penetration testing

DCE dichloroethene

ND GC no data gas chromatogram soil gas samples were not analyzed due to GC malfunction

NP ACC not performed access soil gas sampling was not performed at this location due to safety concerns associated with mobilizing the rig down the hillside to the sampling location located below the steep face of the landfill along the western boundary of the East Landfill Pond

NP DUP not performed duplication of effort soil gas sampling was not performed at this location because two other locations (CPT01593 and CPT02293) encountered the burned sediments of the West Landfill Pond and soil gas samples were collected from these locations

NP REF not performed refusal soil gas sampling was not performed at this location due to shallow refusals encountered at this site during the CPT investigation

TCA trichloroethane

TCE trichloroethene

Table 2-4
Analytes Detected in Leachate at the Seep (SW097)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UT _{Leach} Concentration	Units	PCOC
METALS										
ALUMINUM	10 - 30000	16/19	29	26900	-	-	2629	39136	µg/L	
ANTIMONY	0.05 - 60	4/18	14	60.4	-	A	20	20054	µg/L	1
ARSENIC	0.7 - 10	8/16	1.4	3	B	-	3	3485	µg/L	
BARIUM	0.02 - 50000	19/19	297	1550	-	-	645	63510	µg/L	2
BERYLLIUM	0.2 - 5	2/18	0.2	1.4	-	JA	1	1702	µg/L	
CADMIUM	0.1 - 16.5	4/18	1	7.6	-	-	3	1760	µg/L	
CALCIUM	14.5 - 100000	19/19	126000	212000	-	-	151737	56909	µg/L	1,2,3
CHROMIUM	2.4 - 27.5	7/18	2	29.6	-	-	9	3328	µg/L	
COBALT	0.02 - 50	10/18	2.7	19.1	B	-	11	16938	µg/L	
COPPER	2.4 - 25	8/18	2	94.9	-	-	12	8281	µg/L	
IRON	4.7 - 30000	19/19	61300	155000	-	-	81005	16477	µg/L	2
LEAD	0.8 - 2000	14/18	1.5	11	-	V	5	1482	µg/L	
LITHIUM	2 - 2000	15/19	34	107	-	V	48	35577	µg/L	2
MAGNESIUM	0.1 - 200000	19/19	29300	49000	-	-	34868	1156026	µg/L	2,3
MANGANESE	1 - 10000	19/19	1320	2490	-	-	1623	3024	µg/L	2
MERCURY	0.02 - 0.2	1/18	0.1	0.28	-	-	0.1	58.9	µg/L	
MOLYBDENUM	5.7 - 200	6/18	4	28.5	B	-	21	32559	µg/L	
NICKEL	0.02 - 40	5/18	5	31	-	V	12	13308	µg/L	
POTASSIUM	10 - 200000	18/19	5000	11700	-	-	6511	1607524	µg/L	2,3
SELENIUM	1.1 - 5	2/18	1.1	7	W	-	2	1710	µg/L	
SILVER	2.6 - 25	8/18	2.7	16.7	-	-	5	3388	µg/L	
SODIUM	10 - 50000	19/19	57700	110000	-	V	71468	39331	µg/L	1,2,3
STRONTIUM	3.5 - 10000	17/19	814	1370	-	-	920	241118	µg/L	2

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Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UTL _{95%} Concentration	Units	PCOC
TIN	10 200	8/18	11	243	-	-	48	33576	µG/L	
VANADIUM	3.2 10000	12/19	3.1	211	-	-	25	16634	µG/L	
ZINC	1.8 10000	19/19	857	16000	-	-	2974	3708	µG/L	1 2
PESTICIDES										
alpha BHC	0.05 0.28	1/3	0	0	I	-	0.06		µG/L	4.5
RADIONUCLIDES										
AMERICIUM 241	0 0.013	16/16	0.000404	0.02121	-	V	0.007	0.03	PCI/L	
CESIUM 137	0.47 1	14/14	0.21	0.6057	J	-	0.15	2.1	PCI/L	
GROSS ALPHA	1.5 7.4	8/8	0.8918	6.639	-	V	2.9	29	PCI/L	
GROSS BETA	1.69 11.5	8/8	3.753	17	-	V	10	31	PCI/L	1,2
PLUTONIUM-238	0.01 0.01	2/2	0.000465	0.00222	J	A	0.00088	0.025	PCI/L	
PLUTONIUM 239	0.003 0.003	1/1	0.009	0.009	-	-	0.009		PCI/L	
PLUTONIUM 239/240	0 0.013	16/16	0.001	0.01606	-	A	0.007		PCI/L	
RADIUM 226	0.03 0.03	1/1	0.58	0.58	-	A	0.58	17	PCI/L	
STRONTIUM-89,90	0.21 - 1	9/9	0.66	4.06	-	V	1.35	4.9	PCI/L	1 2
STRONTIUM 90	0.2 0.59	3/3	0.5442	1.1	-	-	0.7		PCI/L	
TRITIUM	155 450	19/19	185.4	1500	-	A	393	732	PCI/L	2
URANIUM 233 234	0.1 0.6	12/12	0.0238	4.2	B	A	0.8		PCI/L	
URANIUM 235	0 0.6	12/12	-0.012	0.084	J	A	0.03	0.3	PCI/L	
URANIUM 238	0.086 0.6	12/12	0.03914	3.76	-	A	1	1.8	PCI/L	
SEMIVOLATILE ORGANICS										
2,4 DIMETHYLPHENOL	10 10	1/5	3	3	J	A	5		µG/L	4
2 METHYLNAPHTHALENE	10 - 10	5/5	12	23	-	V	16		µG/L	4
4 METHYLPHENOL	10 10	3/5	2	4	J	-	4		µG/L	4
ACENAPHTHENE	10 10	5/5	2	3	J	A	3		µG/L	4

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UT _{Low} Concentration	Units	PCOC
BIS(2 ETHYLHEXYL)PHTHALATE	10 12	1/5	2	2	J	A	5	8	µG/L	4
DIBENZOFURAN	10 10	5/5	1	2	J	A	1		µG/L	4
DIETHYL PHTHALATE	10 10	4/5	1	3	J	A	3	8	µG/L	4
FLUORENE	10 10	5/5	2	3	J	A	2		µG/L	4
NAPHTHALENE	10 10	5/5	14	22	-	V	18		µG/L	4
PHENANTHRENE	10 10	5/5	4	5	J	A	4		µG/L	4
VOLATILE ORGANICS										
1,1 DICHLOROETHANE	5 5	17/20	2	10	-	V	6		µG/L	4
1,2 DICHLOROETHENE	5 5	10/20	2	14	-	V	4	3	µG/L	4
2 BUTANONE	10 10	6/19	6	76	-	V	12	19	µG/L	4
2 HEXANONE	10 10	1/20	1	10	-	V	5		µG/L	4
4 METHYL 2-PENTANONE	10 10	5/20	10	87	J	A	11		µG/L	4
ACETONE	10 10	10/20	10	220	-	A	34	29	µG/L	4
BENZENE	5 5	11/20	1	2	J	-	2	3	µG/L	4
CARBON DISULFIDE	5 5	1/20	5	6	-	-	3	4	µG/L	4,5
CHLOROETHANE	10 10	15/20	10	57	-	V	22		µG/L	4
CHLOROMETHANE	10 10	2/20	4	7	J	A	5		µG/L	4
ETHYLBENZENE	5 5	19/20	1	18	-	-	13		µG/L	4
METHYLENE CHLORIDE	5-5	9/20	3	190	B	-	14	21	µG/L	4,5
o XYLENE	5 5	3/4	5	8	-	-	6		µG/L	4
TETRACHLOROETHENE	5 5	2/20	1	1	J	-	2	3	µG/L	4,5
TOLUENE	5 5	19/20	5	88	-	-	38	3	µG/L	4
TOTAL XYLENES	5 5	19/20	1	25	J	A	14	3	µG/L	4
TRICHLOROETHENE	5 5	11/20	1	4	J	-	2	3	µG/L	4
VINYL ACETATE	10-10	1/19	10	49	-	-	7		µG/L	4,5
VINYL CHLORIDE	10 10	5/20	3	11	-	V	5		µG/L	4

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UT _{base} Concentration	Units	PCOC
INDICATOR PARAMETERS										
BICARBONATE AS CaCO ₃	1000 10000	15/15	554000	705000	—	V	595800		µG/L	
CARBONATE AS CaCO ₃	1000 10000	2/9	0	0	—	—	3889		µG/L	
CHLORIDE	100 0 50000	14/14	1800 0	66300 0	—	V	53650	64366	µG/L	
CYANIDE	10 20	1/14	1 5	36 8	—	—	9	252	µG/L	
DISSOLVED ORGANIC CARBON	1000 1000	4/4	14000	27000	—	JA	18750	16997	µG/L	
FLUORIDE	100 0 200 0	12/12	390 00	540 00	—	V	469 2	643	µG/L	
NITRATE/NITRITE	20 00 200 0	6/10	20 00	870 00	—	V	263 0	3130	µG/L	
NITRITE	20 00 20 00	6/9	20 00	63 000	—	V	30 33	1576	µG/L	2
OIL AND GREASE	200 0 11100 0	4/12	800 0	42100 0	—	V	7013	14681	µG/L	
ORTHOPHOSPHATE	10 00 200 0	3/10	50 00	150 00	—	—	60 9	210	µG/L	
pH		5/5	6 8	7 3	—	—	7		PH	
PHOSPHORUS	50 00 1000	9/9	95 000	1380	—	—	387	272	µG/L	
SILICA	400 0 2000	3/3	7400 0	43000	—	—	19567	36561	µG/L	
SILICON	7 3 2000	13/13	7060	44000	—	—	13547	16293	µG/L	
SOLIDS NONVOLATILE SUSPENDED	5000 5000	6/6	10000	199000	—	—	83167		µG/L	
SULFATE	200 0 25000	5/14	200 0	29600 0	—	V	5084	41114	µG/L	
TOTAL DISSOLVED SOLIDS	10000 10000	15/15	470000	870000	—	—	729333	372696	µG/L	
TOTAL ORGANIC CARBON	1000 1000	3/3	19000	24500 0	—	V	20833	21993	µG/L	
TOTAL SUSPENDED SOLIDS	4000 5000	12/12	10000	250000	—	—	144667	157368	µG/L	

All analytes are total analytes unless otherwise noted

For non-detects one half the detection limit is used in calculating the mean result.

- 1 Analyte determined to be PCOC by hot measurement test
- 2 Analyte determined to be PCOC by inferential statistics test(s)
- 3 Analyte not considered a PCOC because it is a nutrient.
- 4 All detected organic analytes are considered PCOCs unless eliminated by professional judgement
- 5 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples

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Analyte removed from consideration as PCOC

Data Qualifiers

- data qualifier or validation field in database is blank
- B for organics reported value is < CRDL but > IDL (estimated value)
- B for organics analyte is also detected in blank for common lab contaminants include as detection if blank result > 10 times detection limit for all other organics include if blank result > 5 times detection limit
- B for radionuclides constituent also detected in blank whose concentration was > minimum detectable activity
- I for organics interference with target peak (estimated value)
- J for organics data indicate presence of compound but below detection limit (estimated value)
- U for organics and organics analyte analyzed but not detected at the quantization limit

Data Validation Codes

- data qualifier field in database is blank
- A acceptable result
- JA acceptable result (for estimated value)
- V valid result

Definitions

- PCOC potential contaminant of concern
- UTL₉₉₉₉ upper tolerance limit of the 99th percentile at the 99 percent confidence level
- CRDL contract required detection limit
- IDL instrument detection limit

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Table 2-5
Analytes Detected in Surface Water in the East Landfill Pond (SW098)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UT ^{see} Concentration	Units	PCOC
METALS										
ALUMINUM	10 - 200	16/22	30.4	271	-	-	75	39136	µG/L	
ANTIMONY	0.05 - 500	2/22	8	16.9	B	-	22	20054	µG/L	
ARSENIC	0.7 - 10	9/21	0.9	2.2	-	V	1	3485	µG/L	2
BARIUM	0.02 - 200	22/22	16	250	-	V	172	63510	µG/L	
BERYLLIUM	0.2 - 5	1/22	0.5	0.7	-	JA	1	1702	µG/L	
CADMIUM	0.1 - 5	1/22	1	2.1	-	JA	1	1760	µG/L	
CALCIUM	14.3 - 5000	22/22	3180	55000	-	V	39972	56909	µG/L	2, 3
CESIUM	5 - 2500	2/23	33	50	B	-	211	475272	µG/L	
CHROMIUM	2.4 - 20	2/22	2	10.9	-	-	3	3328	µG/L	
COPPER	2.1 - 25	8/22	2	16	-	JA	5	8281	µG/L	
IRON	4.3 - 100	22/22	16.3	1150	-	V	507	16477	µG/L	
LEAD	0.8 - 20	7/21	0.9	5.3	-	JA	2	1482	µG/L	
LITHIUM	2 - 100	20/21	7.7	109	-	-	79	35577	µG/L	2
MAGNESIUM	0.1 - 5000	22/22	4270	48300	-	-	39349	1156026	µG/L	2, 3
MANGANESE	1 - 15	21/22	2.5	430	-	V	105	3024	µG/L	2
MERCURY	0.2 - 0.2	3/22	0.1	0.54	-	V	0.1	58.9	µG/L	
MOLYBDENUM	5.7 - 500	3/21	3	13.1	B	-	20	32559	µG/L	2
NICKEL	0.02 - 40	14/22	6.3	22	-	V	10	13308	µG/L	2
POTASSIUM	10 - 5000	22/22	1360	10900	-	V	8754	1607524	µG/L	2, 3
SILICON	7.3 - 100	14/14	298	3670	-	V	2302	16293	µG/L	
SILVER	2.5 - 30	3/22	2	4	-	JA	3	3388	µG/L	
SODIUM	10 - 5000	22/22	19900	196000	-	-	161177	39331	µG/L	1, 2, 3
STRONTIUM	2.3 - 200	21/21	44.9	598	-	-	476	241118	µG/L	2

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UT ⁹⁹⁹⁹ Concentration	Units	PCOC
THALLIUM	0.1 - 10	2/21	1	7.4	-	JA	2	6503	µG/L	2
TIN	10 - 1000	6/21	10	44.3	B	-	41	33576	µG/L	2
VANADIUM	2 - 50	5/22	2	9	B	-	4	16634	µG/L	
ZINC	1.8 - 20	19/22	4	105	-	-	17	3708	µG/L	
RADIONUCLIDES										
AMERICIUM 241	0 - 0.19	15/15	0.0005655	0.031	U	A	0.007	0.03	PC/L	12
CESIUM 137	0.23 - 1.16	11/11	0.2323	0.1344	-	V	0.06	2.1	PC/L	
GROSS ALPHA	2 - 8.68	11/11	0.67	5	U	V	2	29	PC/L	2
GROSS BETA	2.57535 - 7.6	11/11	7.9	16	-	V	11	31	PC/L	2
PLUTONIUM 239	0 - 0.03	6/6	0	0.022	-	-	0.007		PC/L	
PLUTONIUM 239/240	0 - 0.01	11/11	0.000364	0.023	-	A	0.004		PC/L	
RADIUM 226	0.211 - 0.211	1/1	0.23	0.23	-	V	0.23	17	PC/L	
STRONTIUM 89/90	0.23 - 1	5/5	0.6635	1.924	-	A	1.4	4.9	PC/L	2
STRONTIUM 90	0.36 - 0.58	5/5	0.7084	1.208	-	V	1.02		PC/L	
TRITIUM	160 - 460	20/20	10	257.8	J	V	139	732	PC/L	2
URANIUM 233/234	0 - 0.232	9/9	0.7626	1.594	-	V	1.1		PC/L	
URANIUM 235	0 - 0.281	9/9	0.01	0.3	-	A	0.1	0.3	PC/L	12
URANIUM 238	0.08 - 0.263	9/9	0.6996	1.964	-	A	1.1	1.8	PC/L	12
SEMIVOLATILE ORGANICS										
BIS(2 ETHYLHEXYL)PHTHALATE	9 - 11	1/8	1	1	J	A	5	8	µG/L	4
DI n BUTYL PHTHALATE	9 - 11	1/8	1	1	J	A	5		µG/L	4
VOLATILE ORGANICS										
ACETONE	10 - 10	1/21	6	12	B	-	6	29	µG/L	4.5
METHYLENE CHLORIDE	5 - 5	3/21	4	8	B	-	3	21	µG/L	4.5
VINYL ACETATE	10 - 10	1/20	10	80	-	-	9		µG/L	4.5

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Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UT ^{case} Concentration	Units	PCOC
INDICATOR PARAMETERS										
BICARBONATE AS CaCO ₃	1000 10000	16/16	213000	489000	—	V	391063		µG/L	
CARBONATE	10000 10000	1/4	10000	15300 0	—	V	7575	10987	µG/L	
CARBONATE AS CaCO ₃	1000 10000	9/12	0	76500 0	—	V	28167		µG/L	
CHLORIDE	200 0 25000	16/16	137000	190000	—	—	164875	64366	µG/L	
DISSOLVED ORGANIC CARBON	1000 2000	6/6	21900 0	32400 0	—	V	27250	16997	µG/L	
FLUORIDE	100 0 200 0	15/15	590 00	890 00	—	—	770 0	643	µG/L	
NITRATE	100 0 100 0	1/3	100 0	200 0	—	JA	100 0		µG/L	
NITRATE/NITRITE	20 00 100 0	6/13	20 00	320 00	—	JA	80 0	3130	µG/L	
OIL AND GREASE	200 0 7100 0	3/14	400 0	800 0	—	—	2289	14681	µG/L	
ORTHOPHOSPHATE	10 00 50 00	2/11	40 00	40 00	—	—	27 73	210	µG/L	
pH		4/4	8 2	8 3		—	8 2		PH	
PHOSPHORUS	50 00 1000	3/10	50 00	638	B	—	96	272	µG/L	
SILICA	400 0 2000	5/5	2300 0	12000	—	—	6360	36561	µG/L	
SOLIDS NONVOLATILE SUSPENDED	5000 5000	2/6	5000	12000	—	V	4667		µG/L	
SULFATE	500 0 10000	16/16	7000	25600 0	—	V	16031	41114	µG/L	
TOTAL DISSOLVED SOLIDS	10000 10000	16/16	230000	814000	—	V	705125	372696	µG/L	
TOTAL ORGANIC CARBON	1000 2000	6/6	26000	51000	—	—	33633	21993	µG/L	
TOTAL SUSPENDED SOLIDS	4000 5000	3/11	4000	4900000	—	—	448864	157368	µG/L	

All analytes are total analytes unless otherwise noted

For non-detects one-half the detection limit is used in calculating the mean result

- 1 Analyte determined to be PCOC by hot measurement test
- 2 Analyte determined to be PCOC by inferential statistics test(s)
- 3 Analyte not considered a PCOC because it is a nutrient
- 4 All detected organic analytes are considered PCOCs unless eliminated by professional judgment
- 5 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples
Analyte removed from consideration as PCOC

Data Qualifiers

- data qualifier or validation field in database is blank
- B for inorganics reported value is < CRDL but > IDL (estimated value)
- B for organics analyte is also detected in blank for common lab contaminants include as detection if blank result > 10 times detection limit, for all other organics include if blank result > 5 times detection limit
- J for inorganics value > IDL but control sample analysis not within control limits (estimated value)
- J for organics data indicate presence of compound but below detection limit (estimated value)
- U for inorganics and organics analyte analyzed but not detected at the quantitation limit

Data Validation Codes

- data qualifier field in database is blank
- A acceptable result
- JA acceptable result (for estimated value)
- V valid result

Definitions

- CRDL contract required detection limit
- IDL instrument detection limit
- PCOC potential contaminant of concern
- UTL₉₉₉₉ upper tolerance limit of the 99th percentile at the 99-percent confidence level

Table 2-6
Analytes Detected in Sediment in the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{95%} Concentration*	Units	PCOC
METALS											
ALUMINUM	7.7 - 12	2/2	12300	16600	--	V	SED70193	14450	29,600	MG/KG	
ARSENIC	0.32 - 0.42	3/3	2.7	5	--	V	SED70193	4	67	MG/KG	
BARIUM	1.6 - 2.5	3/3	174	215	--	V	SED70093	198	795	MG/KG	
BERYLLIUM	0.22 - 0.34	3/3	0.81	1.5	--	JA	SED70193	1.2	2.6	MG/KG	
CALCIUM	7.5 - 11.7	2/2	6290	7850	--	V	SED70193	7070	80,900	MG/KG	3
CHROMIUM	0.64 - 0.99	3/3	12.3	17.5	--	V	SED70193	14.7	29.5	MG/KG	
COBALT	0.64 - 0.99	3/3	5.7	7.6	--	V	SED70093	6.8		MG/KG	
COPPER	0.71 - 1.1	3/3	11.2	18.6	--	V	SED70193	16.0	175.4	MG/KG	
IRON	1.8 - 2.8	2/2	11600	15400	--	V	SED70193	13500	143,900	MG/KG	
LEAD	2.5 - 3.8	3/3	21.6	33.7	--	V	SED70193	29.7	261.1	MG/KG	
LITHIUM	0.83 - 1.3	2/2	6.1	9.9	--	V	SED70193	8.0		MG/KG	
MAGNESIUM	9.5 - 14.8	2/2	2170	3250	--	V	SED70193	2710	6,470	MG/KG	3
MANGANESE	0.59 - 0.91	2/2	147	186	--	V	SED70193	167		MG/KG	
NICKEL	2.7 - 4.2	3/3	9.3	15.3	--	V	SED70093	12.7	35.2	MG/KG	
POTASSIUM	190 - 295	2/2	1350	2640	--	V	SED70193	1995	3,227	MG/KG	3
SELENIUM	0.3 - 0.5	3/3	0.41	1.1	--	JA	SED70193	0.8	5.2	MG/KG	
SILICON	1.8 - 2.8	2/2	226	344	--	V	SED70193	285		MG/KG	
SILVER	0.88 - 1.4	1/3	0.88	0.88	--	JA	SED70293	0.7		MG/KG	
SODIUM	15 - 23.4	2/2	286	447	--	V	SED70193	367	2,127	MG/KG	3
STRONTIUM	1.3 - 2.1	2/2	43.5	61.5	--	V	SED70193	52.5	356	MG/KG	
TIN	4.1 - 6.3	1/3	5.3	5.3	--	V	SED70293	3.8		MG/KG	
VANADIUM	0.78 - 1.2	3/3	28.8	41	--	V	SED70193	34	86	MG/KG	
ZINC	0.59 - 0.91	3/3	49.2	187	--	V	SED70093	106	148	MG/KG	1

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Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UT _{Lease} Concentration*	Units	PCOC
RADIONUCLIDES											
AMERICIUM 241	0 00210506 0 00417109	3/3	0 00452	0 01789	—	A	SED70093	0 01151		PCI/G	
CESIUM 137	0 0	3/3	0 2863	0 732	X	—	SED70093	0 458	3 51	PCI/G	
GROSS ALPHA	2 45834 3 10666	3/3	11 4	16 42	—	V	SED70193	14 6		PCI/G	
GROSS BETA	1 90451 2 11557	3/3	27 76	28 94	—	V	SED70093	28 3		PCI/G	
PLUTONIUM 239/240	0 00869799 0 0153876	3/3	0 007202	0 09828	—	A	SED70093	0 04480		PCI/G	
STRONTIUM-89 90	0 0419899 0 0737819	3/3	0 1148	0 2366	—	V	SED70093	0 171		PCI/G	
URANIUM 233 234	0 0421662 0 0977679	3/3	0 9126	1 136	—	A	SED70093	1 022		PCI/G	
URANIUM 235	0 0502931 0 0621357	3/3	0 05464	0 07382	—	A	SED70193	0 06158		PCI/G	
URANIUM 238	0 0558886 0 0755938	3/3	0 8104	1 396	—	A	SED70093	1 16		PCI/G	
SEMIVOLATILE ORGANICS											
ACENAPHTHENE	450 790	1/3	100	100	J	A	SED70093	220		UG/KG	2
ANTHRACENE	450 790	1/3	160	160	J	A	SED70093	240		UG/KG	2
BENZO(a)ANTHRACENE	450 790	1/3	340	340	J	A	SED70093	300		UG/KG	2
BENZO(a)PYRENE	450 790	1/3	320	320	J	A	SED70093	293		UG/KG	2
BENZO(b)FLUORANTHENE	450 790	1/3	450	470	J	A	SED70093	343		UG/KG	2
BENZO(ghi)PERYLENE	450 790	1/3	200	200	J	A	SED70093	253		UG/KG	2
BENZO(k)FLUORANTHENE	450 790	1/3	130	130	J	A	SED70093	230		UG/KG	2
BENZOIC ACID	2200 3900	3/3	260	870	J	A	SED70093	537		UG/KG	2
BIS(2 CHLOROISOPROPYL)ETHER	450 790	1/3	47	47	J	A	SED70293	259		UG/KG	2
BIS(2 ETHYLHEXYL)PHTHALATE	450 790	1/3	80	80	J	A	SED70093	213		UG/KG	2
CHRYSENE	450 790	1/3	310	310	J	A	SED70093	290		UG/KG	2
FLUORANTHENE	450 790	2/3	79	830	—	V	SED70093	415		UG/KG	2

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL ₉₉₉ Concentration*	Units	PCOC
FLUORENE	450 790	1/3	92	92	J	A	SED70093	217		UG/KG	2
INDENO(1,2,3 cd)PYRENE	450 790	1/3	180	180	J	A	SED70093	247		UG/KG	2
PHENANTHRENE	450 790	2/3	73	630	J	A	SED70093	346		UG/KG	2
PYRENE	450 790	2/3	74	750	J	A	SED70093	386		UG/KG	2
VOLATILE ORGANICS											
2 BUTANONE	13 24	1/3	13	35	—	V	SED70093	17		UG/KG	2
ACETONE	13 24	2/3	63	130	B	V	SED70193	68		UG/KG	2
TOLUENE	10 33	3/3	180	440	—	V	SED70293	307		UG/KG	2
INDICATOR PARAMETERS											
% SOLIDS	0.1 0.1	4/4	42.1	75.8	—	V	SED70293	54.4		%	
pH	0.2 0.2	3/3	6.7	7.2	—	V	SED70193	7.0		PH	
TOTAL ORGANIC CARBON	500 500	3/3	7800	9400	X	V	SED70293	8367		MG/KG	

* Background UTL₉₉₉ concentrations for seep sediment data. There are no background data for pond sediments.

- 1 Analyte determined to be PCOC by hot measurement test
- 2 All detected organic analytes are PCOCs unless eliminated through professional judgment
- 3 Analyte not considered a PCOC because it is a nutrient

Data Qualifiers

- data qualifier field in database is blank
- B for organics: analyte is also detected in blank, for common lab contaminants include as detection if blank result > 10 times detection limit for all other organics include if blank result > 5 times detection limit
- J for organics: data indicate presence of compound but below detection limit (estimated value)
- X for inorganics (pre-1992): detection limit greater than normal sample matrix interference

Data Validation Codes

- data qualifier field in database is blank
- A acceptable result
- JA acceptable result (for estimated value)

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V valid result

Definitions

PCOC potential contaminant of concern

UTL₉₉₉₉ upper tolerance limit of the 99th percentile at the 99-percent confidence level

Table 2-7
Analytes Detected in Soils in the Vicinity of Spray Evaporation Areas

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{Lease} Concentration	Units	PCOC
METALS											
ALUMINUM	3.7 40.0	216/216	5100	24400	—	V	SS700493	12006	25879	MG/KG	
ANTIMONY	3.7 14.5	6/215	3.7	9.1	—	V	SS719693	4	—	MG/KG	1
ARSENIC	0.14 2.6	216/216	1.2	15.7	—	V	SS702293	5	13	MG/KG	1
BARIUM	0.34 40.0	216/216	30	1120	—	V	SS705193	194	532	MG/KG	1
BERYLLIUM	0.06 1.0	161/216	0.36	1.5	—	V	SS120894	1	5.0	MG/KG	2
CADMIUM	0.5 1.7	13/215	0.5	1.5	—	V	SS710493	0	5	MG/KG	
CALCIUM	2.1 1000	215/215	1890	54800	—	V	SS705093	8672	18659	MG/KG	1,2,3
CHROMIUM	0.47 3.3	216/216	4.3	24.7	—	V	SS700493	13	28	MG/KG	
COBALT	0.49 10.0	201/216	2.8	16.2	—	V	SS712093	7	24	MG/KG	2
COPPER	0.47 5.0	216/216	7.1	640	—	V	SS121394	17	30	MG/KG	1,2
IRON	0.89 20.0	216/216	4390	59600	—	V	SS121594	13515	29052	MG/KG	1,3
LEAD	0.16 17.2	216/216	6.4	16.7	—	V	SS708893	26	62	MG/KG	1
LITHIUM	0.58 20.0	84/91	1.9	16.4	—	V	SS121094	8	22	MG/KG	
MAGNESIUM	5.9 1000	215/215	921	7910	—	V	SS700293	2666	7718	MG/KG	1,3
MANGANESE	0.16 3.0	215/215	20.9	1370	—	V	SS700593	215	2100	MG/KG	
MERCURY	0.076 0.17	21/213	0.050	0.14	—	V	SS708693	0.1	—	MG/KG	1
MOLYBDENUM	1.2 - 40.0	16/92	1.4	4.1	—	V	SS702993	1	37	MG/KG	
NICKEL	1.2 8.0	215/216	4.6	23.8	—	V	SS121394	12	27	MG/KG	
POTASSIUM	96.8 1000	216/216	407	3620	—	V	SS711093	1925	6190	MG/KG	3
SELENIUM	0.23 1.0	115/204	0.23	2.9	—	V	SS121594	1	1.4	MG/KG	1,2
SILICON	1.3 2.1	76/76	93.7	628	—	V	SS705393	267	3542	MG/KG	
SILVER	0.51 2.0	66/215	0.53	3	—	V	SS709593	1	—	MG/KG	1
SODIUM	5.6 1000	194/216	22.6	1280	—	V	SS708293	123	1052	MG/KG	1,3
STRONTIUM	0.33 40.0	92/92	22.2	80.6	—	V	SS720193	48	113	MG/KG	2
THALLIUM	0.31 2.0	41/212	0.31	2.1	—	V	SS121594	0.2	2.0	MG/KG	1

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{Leads} Concentration	Units	PCOC
TIN	3.1 - 40.0	5/92	3.1	10	—	V	SS708993	3	70	MG/KG	
VANADIUM	0.6 - 10.0	216/216	9.7	86.2	—	V	SS705293	32	60	MG/KG	1
ZINC	0.42 - 4.0	216/216	21.5	113	—	V	SS120894	56	99	MG/KG	1.2
RADIONUCLIDES											
AMERICIUM 241	0 - 0.033	200/200	0	1.076	—	V	SS703793	0.02	0.058	PCI/G	1.2
CESIUM 134	0 - 0.12	66/66	0.381	0.12	—	V	SS120594	0.02	—	PCI/G	
CESIUM 137	0 - 0.26	210/210	-0.0722	2.27	—	V	SS700893	0	3.5	PCI/G	
GROSS ALPHA	1.1 - 9	214/214	7.2	29	—	V	SS120794	15	43	PCI/G	
GROSS BETA	1.87555 - 5.3	202/202	17.71	42	—	V	SS120794	26	53	PCI/G	
PLUTONIUM 239/240	0 - 0.06	196/196	-0.00101	0.4692	—	V	SS704293	0.05	0.13	PCI/G	1.2
RADIUM 226	0 - 0.51	106/106	0.4355	1.787	—	V	SS711193	1.0	1.5	PCI/G	1.2
RADIUM 228	0 - 0.98	132/132	0.7629	2.597	—	V	SS704493	1.6	4.8	PCI/G	
STRONTIUM 89 90	0.02 - 0.5	214/214	0.004	1.017	—	V	SS708993	0.2	2.1	PCI/G	
URANIUM 233 234	0 - 0.331119	213/213	0.5558	1.5	—	V	SS702593	0.9	1.8	PCI/G	
URANIUM 235	0 - 0.3	213/213	0.0305	0.12	—	V	SS701993	0.0	0.187	PCI/G	
URANIUM 238	0 - 0.331119	213/213	0.5589	1.626	—	V	SS708293	0.9	2.0	PCI/G	
INDICATOR PARAMETERS											
% SOLIDS	0.1 - 0.1	200/200	29.5	91.4	—	V	SS720093	75	129.3	%	
NITRATE/NITRITE	0.50 - 1	164/216	0.68	45	—	V	SS710893	4	9.6	MG/KG	1.2
TOTAL ORGANIC CARBON	0.05 - 500	187/216	0.05	54000	—	V	SS701193	10700	49178	MG/KG	1

- 1 Analyte determined to be PCOC by hot measurement test
- 2 Analyte determined to be PCOC by inferential statistics test(s)
- 3 Analyte not considered a PCOC because it is a nutrient

Data Qualifiers

— data qualifier or validation field in database is blank

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Data Validation Codes

V valid result

Definitions

PCOC potential contaminant of concern

UTL_{99/99} upper tolerance limit of the 99th percentile at the 99 percent confidence level

Table 2-8
Analytes Detected in Subsurface Geologic Materials Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL ₉₉₉ Concentration	Units	PCOC
Colluvial Material (Oc)											
METALS											
ALUMINUM	6.9 - 7.8	7/7	10400	16100	—	V	71093	12657	27862	MG/KG	
ARSENIC	0.24 - 0.36	7/7	3.3	7.9	—	V	70993	5	9	MG/KG	
BARIUM	1.4 - 1.6	7/7	91.4	624	—	JA	71093	230	465	MG/KG	1
BERYLLIUM	0.2 - 0.22	7/7	0.74	1.2	—	JA	70993	1.0	25	MG/KG	
CALCIUM	6.7 - 7.6	7/7	5620	7350	—	V	71093	6404	31386	MG/KG	2
CHROMIUM	0.56 - 0.64	7/7	11.2	16.9	—	V	71093	13.2	37	MG/KG	
COBALT	0.56 - 0.64	7/7	5.6	10.9	—	V	71093	9	17	MG/KG	
COPPER	0.63 - 0.72	7/7	12.6	17.7	—	V	71093	15	33	MG/KG	
IRON	1.6 - 1.9	7/7	12300	18400	—	V	71093	14486	38544	MG/KG	
LEAD	2 - 2.6	7/7	16.5	27.9	—	JA	71093	23	32	MG/KG	
LITHIUM	0.74 - 0.84	7/7	6.1	9.9	—	V	71093	8.0	23	MG/KG	
MAGNESIUM	8.4 - 9.6	7/7	2500	3550	—	V	71093	2923	7873	MG/KG	2
MANGANESE	0.52 - 0.59	7/7	106	262	—	V	70993	198	753	MG/KG	
NICKEL	2.4 - 2.7	7/7	13.1	18.4	—	V	71093	15.2	42.0	MG/KG	
POTASSIUM	169 - 193	7/7	970	1780	—	V	71093	1294	3175	MG/KG	2
SELENIUM	0.26 - 0.34	7/7	0.34	0.74	—	JA	70993	0.52	7	MG/KG	
SILICON	1.6 - 1.8	7/7	315	659	—	JA	71093	410		MG/KG	
SODIUM	133 - 153	7/7	84.5	912	—	V	70993	378	3004	MG/KG	2
STRONTIUM	1.2 - 1.4	7/7	49.9	107	—	V	71093	67	142	MG/KG	
TIN	3.6 - 4.1	5/7	3.7	8.9	—	JA	71093	5.6	626	MG/KG	
VANADIUM	0.69 - 0.79	7/7	20.6	43.6	—	V	71093	28.4	73	MG/KG	
ZINC	0.52 - 0.59	7/7	55	72.2	—	V	71093	61	133	MG/KG	

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Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{95%} Concentration	Units	PCOC
RADIONUCLIDES											
AMERICIUM 241	0 0	6/6	0 001197	0 0143	J	A	71093	0 0061		PCI/G	
CESIUM 137	0 1 0 1	6/6	0 0142	0 2386	-	-	71093	0 0584	0 1	PCI/G	1
GROSS ALPHA	0 8 3 4	6/6	8 03	16 8	-	V	70993	13 6	65	PCI/G	
GROSS BETA	2 3 2 5	6/6	21 88	26 18	-	V	70993	24 0	40	PCI/G	
PLUTONIUM 239/240	0 0 0 16	4/4	0 002438	0 01842	J	A	70993	0 01076		PCI/G	
RADIUM 226	0 5 0 5	6/6	0 8443	1 083	-	-	70993	0 974	2	PCI/G	
RADIUM 228	0 5 0 5	6/6	1 322	1 859	-	-	70993	1 623	3	PCI/G	
STRONTIUM 89 90	0 04 0 06	6/6	0 1022	0 4153	J	A	71093	0 1852	1 2	PCI/G	
TRITIUM	450 450	6/6	97 59	301 5	J	V	70993	170 1	456	PCI/L	
URANIUM 233 234	0 029 0 081	6/6	0 7916	1 166	-	A	71093	0 97		PCI/G	
URANIUM 235	0 000 0 042	6/6	0 02566	0 05357	J	A	70993	0 03664	0 2	PCI/G	
URANIUM 238	0 0 0 57	6/6	0 961	1 233	-	A	71093	1 06	2	PCI/G	
SEMIVOLATILE ORGANICS											
CHRYSENE	380 440	1/7	43	43	J	A	70993	180		UG/KG	3
FLUORANTHENE	380 440	1/7	110	110	J	A	70993	189		UG/KG	3
PHENANTHRENE	380 440	1/7	100	100	J	A	70993	188		UG/KG	3
PYRENE	380 440	1/7	110	110	J	A	70993	189		UG/KG	3
VOLATILE ORGANICS											
4 METHYL 2 PENTANONE	12 14	1/5	12	58	-	V	70993	17		UG/KG	3
TOLUENE	12 64	5/5	160	2000	-	V	70993	850		UG/KG	3
TOTAL XYLENES	6 7	1/5	2	2	J	A	70993	3		UG/KG	3
INDICATOR PARAMETERS											
% SOLIDS	0 1 0 1	7/7	73 9	85 6	-	V	71093	81		%	
NITRATE	1 1	2/5	1	2	-	JA	70993	1		MG/KG	
NITRATE/NITRITE	1 1	3/5	1	20000	-	V	71093	4001	66	MG/KG	1

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{95%} Concentration	Units	PCOC
TOTAL ORGANIC CARBON	0.05 - 0.05	5/5	500	21000	-	V	71093	8540		MG/KG	
pH	0.2 - 0.2	7/7	7.8	8.4	-	V	70993	8.1		PH	
Weathered Bedrock Material (KaKI-w)											
METALS											
ALUMINUM	5.8 - 7.5	11/11	5320	7880	-	V	70993	7035	43375	MG/KG	
ARSENIC	0.19 - 1.4	11/11	13	11.4	-	V	70993	3.4	10	MG/KG	1
BARIUM	1.2 - 1.5	11/11	24.5	254	-	JA	71093	97	205	MG/KG	1
BERYLLIUM	0.16 - 0.21	11/11	0.53	1.1	-	JA	71093	1	9	MG/KG	
CADMIUM	0.49 - 0.64	4/11	0.49	1.5	-	V	71093	0.5		MG/KG	
CALCIUM	5.6 - 7.3	11/11	2770	15900	-	V	71093	6036	8274	MG/KG	12
CHROMIUM	0.48 - 0.61	11/11	6.4	10.6	-	V	71093	8	52.7	MG/KG	
COBALT	0.48 - 0.61	11/11	2.2	21	-	V	71093	9	17	MG/KG	1
COPPER	0.53 - 0.68	11/11	13.2	24.3	-	V	71093	19	44.0	MG/KG	
IRON	1.4 - 1.8	11/11	4880	24600	-	V	71093	13893	36178	MG/KG	
LEAD	1 - 2.3	11/11	12.6	31.2	-	JA	70993	22	26	MG/KG	1
LITHIUM	0.62 - 0.8	11/11	3.4	10	-	V	70993	7	24	MG/KG	
MAGNESIUM	7.1 - 9.2	11/11	1840	3130	-	V	71093	2470	7221	MG/KG	2
MANGANESE	0.44 - 0.57	11/11	20.2	896	-	JA	71093	275	706	MG/KG	1
MERCURY	0.08 - 0.11	2/11	0.08	0.18	-	JA	70993	0.1		MG/KG	
NICKEL	2 - 2.6	11/11	3.1	38.2	-	V	71093	17	52	MG/KG	
POTASSIUM	143 - 184	11/11	830	1330	-	V	71093	993	3362	MG/KG	2
SELENIUM	0.23 - 0.3	7/11	0.27	1.9	-	JA	71093	0.8		MG/KG	
SILICON	1.3 - 1.7	11/11	224	1200	-	JA	71093	589		MG/KG	
SILVER	0.66 - 0.85	2/11	0.66	0.89	-	V	71093	0.5	62	MG/KG	
SODIUM	11.3 - 14.5	11/11	256	939	-	V	70993	495	2804	MG/KG	2
STRONTIUM	1 - 1.3	11/11	46.6	197	-	V	71093	97	32.2	MG/KG	1
THALLIUM	0.26 - 0.34	2/11	0.28	0.66	-	JA	71093	0.2		MG/KG	
TIN	3.1 - 3.9	4/11	3.1	9.4	-	JA	70993	3.5	629	MG/KG	
VANADIUM	0.59 - 0.75	11/11	10.3	29.2	-	V	71093	19	91	MG/KG	

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{95%} Concentration	Units	PCOC
ZINC	0.44 0.57	11/11	419	84.4	—	JA	71093	70	68	MG/KG	1
RADIONUCLIDES											
AMERICIUM 241	0 0	11/11	0.000329	0.009491	J	A	70993	0.00289		PCI/G	
CESIUM 137	0.1 0.1	11/11	0.0344	0.01489	J	—	70993	0.0039		PCI/G	
GROSS ALPHA	1.9 - 3.4	11/11	5.615	14.18	—	V	70993	10.8		PCI/G	
GROSS BETA	2.3 2.6	11/11	21.21	25.64	—	V	71093	23.7		PCI/G	
PLUTONIUM 239/240	0 0.016	8/8	0	0.007367	J	A	71093	0.003372		PCI/G	
RADIUM 226	0.5 0.5	11/11	0.9136	1.312	—	—	70993	1.13	2.5	PCI/G	
RADIUM 228	0.5 0.5	11/11	1.048	1.584	—	—	70993	1.360		PCI/G	
STRONTIUM 89 90	0.04 0.05	11/11	0.02282	0.8017	J	A	71093	0.1849	2.6	PCI/G	
TRITIUM	440 450	11/11	37.7	309.2	J	V	70993	80.2		PCI/L	
URANIUM 233, 234	0.021 0.055	11/11	0.7383	1.408	—	A	70993	1.016		PCI/G	
URANIUM 235	0 0.046	11/11	0.00387	0.1053	J	A	70993	0.0527		PCI/G	
URANIUM 238	0 0.033	11/11	0.8527	1.309	—	A	70993	1.12		PCI/G	
VOLATILE ORGANICS											
1,1 1-TRICHLOROETHANE	6 - 6	1/11	2	2	J	A	70993	3		UG/KG	3 4
TOLUENE	6 110	11/11	120	580	—	JA	70993	309		UG/KG	3
INDICATOR PARAMETERS											
% SOLIDS	0.1 0.1	11/11	82.7	89.4	—	V	71093	87		%	
TOTAL ORGANIC CARBON	0.05 0.05	3/11	500	2600	—	V	71093	700		MG/KG	
pH	0.2 0.2	11/11	7.6	8.6	—	V	71093	8		PH	

Note Sample locations are 70993 and 71093

- 1 Analyte determined to be PCOC by hot measurement test
- 2 Analyte not considered a PCOC because it is a nutrient
- 3 All detected organic analytes are considered PCOC's unless eliminated by professional judgment
- 4 Analyte not considered a PCOC because of infrequent detection and/or detection is in blanks or background samples

Data Qualifiers

- data qualifier or validation field in database is blank
- J for inorganics value > IDL but control sample analysis not within control limits (estimated value)
- J for organics data indicate presence of compound but below detection limit (estimated value)
- V valid result

Data Validation Codes

- data qualifier field in database is blank
- A acceptable result
- JA acceptable result (for estimated value)

Definitions

- QC Quaternary colluvium
- KaKl(w) weathered undifferentiated Arapahoe and Laramie Formation
- PCOC potential contaminant of concern
- UTL₉₉₉₉ upper tolerance limit of the 99th percentile at the 99-percent confidence level

Table 2-9
Completion Information for Wells Downgradient of the Landfill

Location	Formation Completed	Screen Interval (feet bgs)	Hydrostratigraphic Unit	Date Completed
Wells in the Vicinity of the East Landfill Pond				
0786	Qc	3 00-5 74	UHSU	1986
0886	KaKlss(u)	59 08-63 79	LHSU	1986
B206789	KaKl(w)	9 80-19 28	UHSU	1989
B206889	KaKl(w)	8 00-17 45	UHSU	1989
Wells Downgradient of the Dam				
4087	Qvf	3 50-6 46	UHSU	1987
4187	KaKlss(u)	81 21-93 79	LHSU	1987
4287	Qvf	3 00-6 36	UHSU	1987
B206989	KaKl(w)	11 80-21 30	UHSU	1989
B207089	KaKlss(u)	31 32-57 98	UHSU	1989
52894	Qvf	3 00-4 00	UHSU	1994
52994	KaKl(w)	7 50-15 00	UHSU	1994
53094	KaKlss(u)	55 00-65 00	LHSU	1994
53194	Qvf	4 50-7 00	UHSU	1994

KaKl(w) weathered undifferentiated Arapahoe and Laramie Formation

KaKlss(u) unweathered undifferentiated Arapahoe and Laramie Formation

Qc colluvium

Qvf valley fill alluvium

bgs below ground surface

UHSU upper hydrostratigraphic unit

LHSU lower hydrostratigraphic unit

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Table 2-10
Analytes Detected in UHSU Groundwater in the Vicinity of Spray Evaporation Areas

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{Lease} Concentration	Units	PCOC
METALS											
ALUMINUM	16 200	7/7	217	635	—	V	B206789	385	26324	µG/L	
ANTIMONY	17 60	1/7	14.00	58	B	Y	B206789	18	52	µG/L	1
ARSENIC	2 10	1/7	1	27	—	V	B206789	1	8	µG/L	
BARIUM	9 200	4/7	16.1	22	B	Y	B206789	16	311	µG/L	
CALCIUM	17 5000	7/7	151000	167000	—	V	B206789	158000	148662	µG/L	1 2 3
CESIUM	20 1000	1/6	23	45	B	Y	B206789	122	866	µG/L	
CHROMIUM	3 10	2/7	2.00	17	—	JA	B206789	4	192	µG/L	
COPPER	2 25	1/7	2	8	B	Y	B206789	4	42	µG/L	
IRON	5 100	7/7	238	527	—	V	B206789	383	32398	µG/L	
LEAD	1 5	2/7	1	12	B	V	B206789	1	20	µG/L	
LITHIUM	2 100	7/7	186	225	—	Y	B206789	207	177	µG/L	1 2
MAGNESIUM	36 - 5000	7/7	40700	44900	—	V	B206789	42500	33725	µG/L	1 2,3
MANGANESE	1 15	5/7	2.8	9.7	—	V	B206789	6.3	643	µG/L	
NICKEL	10 40	1/7	3	11.1	B	Y	B206789	5	101	µG/L	
POTASSIUM	620 - 5000	6/7	3640	3760	B	V	B206789	3489	5243	µG/L	2 3
SELENIUM	0 5	7/7	488	815	+	JA	B206789	665	131	µG/L	1 2
SILICON	13 100	6/6	5950.00	7170	—	V	B206789	6447	62830	µG/L	
SILVER	4 10	1/7	2	10.90	N	JA	B206789	3	7	µG/L	1 2
SODIUM	21 - 5000	7/7	139000	148000	—	V	B206789	144429	147829	µG/L	1,2,3
STRONTIUM	1 200	7/7	1360	1560	—	V	B206789	1446	1110	µG/L	1 2
THALLIUM	2 10	1/7	1	1	B	V	B206789	1	9	µG/L	
TIN	18 200	1/7	10	192	B	V	B206789	12	170	µG/L	
VANADIUM	3 50	3/7	2.90	8.9	BE	JA	B206789	5	71	µG/L	

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{99.99} Concentration	Units	PCOC
ZINC	3 20	4/7	9 1	52 7	—	JA	B206789	19 3	184	µG/L	
RADIONUCLIDES											
AMERICIUM 241	0 01 0 01	1/1	0 433	0 433	J	—	B206789	0 433	0 04	PCI/L	
GROSS ALPHA	9 2 9 2	1/1	53 9	53 9	—	V	0786	53 9	391	PCI/L	
GROSS BETA	8 6 8 6	1/1	29 4	29 4	—	V	0786	29 4	221	PCI/L	
PLUTONIUM 239/240	0 01 0 01	2/2	0 001103	0 004	—	A	B206789	0 003		PCI/L	
RADIUM 226	0 06 0 5	2/2	0 35	0 52	—	A	B206789	0 44	1 29	PCI/L	
TRITIUM	210 840	28/28	164 49541	368	J	V	0786	82	13413	PCI/L	
URANIUM 233 234	0 0	1/1	49 32	49 32	—	A	B206889	49 32		PCI/L	
URANIUM 235	0 07 0 07	1/1	2 62	2 62	—	A	B206889	2 62	5 2	PCI/L	
URANIUM 238	0 07 0 18	2/2	29 81	35 45	—	A	B206889	32 63	1 14	PCI/L	2
SEMIVOLATILE ORGANICS											
BIS(2 ETHYLHEXYL)PHTHALATE	10 0000 10 0000	1/2	3	3	J	A	B206789	4		µG/L	4
VOLATILE ORGANICS											
1,1-DICHLOROETHANE	0 1000 10	1/51	0 1	0 3	—	V	0786	2	3	µG/L	4,5
ACETONE	10 - 100	2/41	9	24	B	—	B206889	8	16	µG/L	4,5
BENZENE	0 1000 10	2/51	0 1	0 5	J	A	B206889	2	3	µG/L	4,5
CARBON TETRACHLORIDE	0 2000 10	2/51	0 2	7 11	—	Y	B206889	2	516	µG/L	4
CHLOROETHANE	0 4000 - 10	2/51	0 4	3	J	A	0786	4		µG/L	4,5
ETHYLBENZENE	0 2000 10	1/51	0 2	0 3	J	A	B206889	2		µG/L	4,5
METHYLENE CHLORIDE	0 1000 - 10	7/51	0 1	8	B	—	B206889	2	16	µG/L	4,5
TETRACHLOROETHENE	0 1000 - 10	1/51	0 1	0 769	—	Y	B206889	2	44	µG/L	4
TOLUENE	0 1000 - 10	1/51	0 1	3	J	A	B206889	2	4	µG/L	4,5
TOTAL XYLENES	0 5 - 10	1/46	0 5	3	J	A	B206889	3	3	µG/L	4,5
TRICHLOROETHENE	0 1000 10	1/51	0 1	1 43	—	Y	B206889	2	38	µG/L	4

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{99.95} Concentration	Units	PCOC
INDICATOR PARAMETERS											
BICARBONATE AS CaCO_3	1000 10000	21/21	135000	860000	—	V	0786	316225		$\mu\text{G/L}$	1 2
CARBONATE AS CaCO_3	1000 10000	4/13	0	1430 00	B	V	B206789	1264		$\mu\text{G/L}$	
CHEMICAL OXYGEN DEMAND	5000 - 10000	9/10	10000	55000 0	—	Y	0786	24456		$\mu\text{G/L}$	
CHLORIDE	200 0 25000	21/21	59000	460000	—	V	B206889	155697	63635	$\mu\text{G/L}$	1 2
FLUORIDE	100 0 200 0	20/20	300	1900 0	—	V	0786	692 0	2024	$\mu\text{G/L}$	
NITRATE/NITRITE	20 00 - 200000	34/38	20 00	290000	—	JA	B206889	48704	55685	$\mu\text{G/L}$	1 2
ORTHOPHOSPHATE	10 00 50 00	4/7	10 00	30 00	—	—	B206789	20 71	53	$\mu\text{G/L}$	2
pH		2/2	7 1	7 7	—	—	B206789	7 4		PH	
SILICA	400 0 2000	8/8	5500	25000	—	JA	B206789	9000	35735	$\mu\text{G/L}$	
SODIUM FLUORIDE	100 0 100 0	1/1	520	520 00	—	V	B206789	520 00		$\mu\text{G/L}$	
SODIUM SULFATE	20000 20000	1/1	524000	524000	—	V	B206789	524000		$\mu\text{G/L}$	
SOLIDS NONVOLATILE SUSPENDED	5000 5000	1/1	29000	29000	—	JA	B206889	29000		$\mu\text{G/L}$	
SULFATE	2000 250000	20/20	170000	1600000	—	V	B206889	621840	613607	$\mu\text{G/L}$	1 2
TOTAL DISSOLVED SOLIDS	5000 14000	21/21	1140000	3700000	—	V	B206889	1521476	1290550	$\mu\text{G/L}$	1 2
TOTAL ORGANIC CARBON	1000 5000	14/14	3000	22000	—	V	0786	8975		$\mu\text{G/L}$	
TOTAL SUSPENDED SOLIDS	4000 5000	19/20	5000	590000	—	—	B206789	63675	1402588	$\mu\text{G/L}$	

All analytes are total analytes unless otherwise noted

Organic analytes with zero hits are not reported

Metal analytes with zero hits are reported

All radionuclide results are considered hits

The minimum result may be a hit or not a hit

The maximum detection may only be a hit

In calculating the mean one-half of the detection limit is used for those results that are not hits

- 1 Analyte determined to be PCOC by hot measurement test
- 2 Analyte determined to be PCOC by inferential statistics test(s)
- 3 Analyte not considered a PCOC because it is a nutrient
- 4 All detected organic analytes are considered PCOC's unless eliminated by professional judgment
- 5 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples

Data Qualifiers

- data qualifier field in database is blank
- + correlation coefficient for matrix spike analysis is less than 0.995 (estimated value)
- B for inorganics reported value is < CRDL but > IDL (estimated value)
- B for organics analyte is also detected in blank for common lab contaminants include as detection if blank result > 10 times detection limit for all other organics include if blank result > 5 times detection limit
- E for inorganics value is an estimate due to interference (estimated value)
- J for inorganics value > IDL but control sample analysis not within control limits (estimated value)
- J for organics, data indicate presence of compound but below detection limit (estimated value)
- N for inorganics spiked sample recovery is not within control limits (estimated value)

Data Validation Codes

- data qualifier or validation field in database is blank
- A acceptable result
- JA acceptable result (for estimated value)
- V valid result
- Y analytical results in validation process

Definitions

- CRDL contract required detection limit
- IDL instrument detection limit
- PCOC potential contaminant of concern
- UTL_{99.99} upper tolerance limit of the 99th percentile at the 99-percent confidence level

Table 2-11
Analytes Detected in UHSU Groundwater Downgradient of the Dam

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UT _{Lease} Concentration	Units	PCOC
METALS											
ALUMINUM	200 200	7/8	141	3080	—	—	4287	938	26324	µG/L	
ANTIMONY	60 60	1/8	8	66.8	—	JA	B207089	17	52	µG/L	1 5
ARSENIC	10 10	1/8	1	1.9	B	—	4287	1	8	µG/L	
BARIUM	200 200	7/8	27.5	94.5	B	—	4287	45	311	µG/L	
CADMIUM	5 5	2/8	1	2.4	B	V	B207089	1	4	µG/L	
CALCIUM	5000 5000	8/8	77800	149000	—	V	B207089	127400	148662	µG/L	1 2 3
CHROMIUM	10 10	5/8	2.5	18	—	V	B207089	7	192	µG/L	
COPPER	25 25	2/8	3.5	9.4	B	—	4287	4	42	µG/L	
IRON	100 100	8/8	124	2890	—	—	4287	888	32398	µG/L	
LEAD	3 5	2/8	1	2.6	B	—	4287	1	20	µG/L	
LITHIUM	100 100	8/8	13.5	138	—	V	B207089	100	177	µG/L	2
MAGNESIUM	5000 - 5000	8/8	11300	44100	—	V	B207089	34313	33725	µG/L	1,2,3
MANGANESE	15 15	8/8	14.1	109	—	V	B207089	47	643	µG/L	
MOLYBDENUM	200 200	2/8	2	7.3	B	V	B207089	4	204	µG/L	
NICKEL	40 40	4/8	4	8.4	B	—	4287	6	101	µG/L	
POTASSIUM	5000 5000	8/8	1290	6730	—	V	B207089	5194	5243	µG/L	1,2,3
SELENIUM	5 5	1/8	1	1	B	JA	B207089	1	131	µG/L	
SILICON	100 100	4/4	2720	13300	N	JA	4287	5615	62830	µG/L	
SILVER	10 10	2/7	2	3.2	B	—	4287	2	7	µG/L	
SODIUM	5000 - 5000	7/7	23200	465000	—	V	B207089	330300	147829	µG/L	1,2,3
STRONTIUM	200 200	7/7	412	1870	—	V	B207089	1355	1110	µG/L	1 2
TIN	200 200	2/7	10	20.2	B	V	B207089	12	170	µG/L	
VANADIUM	50 50	5/7	5	32.1	B	—	4287	13	71	µG/L	

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{Leads} Concentration	Units	PCOC
ZINC	20 20	5/7	113	334	—	V	B207089	22.1	184	µG/L	
RADIONUCLIDES											
AMERICIUM 241	0 0.030	23/23	0	0.012	—	A	B207089	0.005	0.04	PC/L	
CESIUM 134	2.21 2.21	1/1	0.64	0.64	—	—	B207089	0.64		PC/L	
CESIUM 137	0.6 2.37	10/10	0.498	0.4298	J	A	B207089	0.0	1.1	PC/L	
GROSS ALPHA	4.8 74.07	2/2	0	19	—	Y	B207089	10	391	PC/L	
GROSS BETA	10 21.82	2/2	3.46	13	—	Y	B207089	8	221	PC/L	
PLUTONIUM 238	0.00314 0.01	2/2	0.002318	0.01164	—	—	B207089	0.00698	0.04715	PC/L	
PLUTONIUM 239/240	0 0.087	25/25	0.000272	0.009	J	V	B207089	0.002		PC/L	
RADIUM 226	0.096 0.096	1/1	0.64	0.64	B	Y	B207089	0.64	1.29	PC/L	
STRONTIUM 89 90	0.25 1.6	4/4	0.14	0.49	—	A	4287	0.17	1.2	PC/L	2
STRONTIUM 90	0 0	1/1	1.31	1.31	—	—	B207089	1.31		PC/L	
TRITIUM	0 820	37/37	141	400	U	—	B207089	97	13413	PC/L	
URANIUM 233 234	0 0.61	4/4	2.8	20.09	—	A	4087	7.8		PC/L	
URANIUM 235	0 0.74	4/4	0.082	0.7962	—	A	4287	0.456	5.2	PC/L	
URANIUM 238	0 0.61	4/4	1.5	13.23	—	A	4087	5.0	114	PC/L	
VOLATILE ORGANICS											
BENZENE	0 1000 - 5	1/53	0.1	0.1	J	—	B207089	2	3	µG/L	4.5
METHYLENE CHLORIDE	0 1000 - 5	10/52	0.1	12	B	—	B207089	2	16	µG/L	4.5
TOLUENE	0 1000 - 5	2/54	0.1	1	J	—	B206989	2	4	µG/L	4.5
INDICATOR PARAMETERS											
AMMONIA	30.0 100.0	5/14	80.00	214.000	—	Y	B207089	75		µG/L	
BICARBONATE AS CaCO ₃	1000 10000	32/32	38000	670000	—	V	B207089	311825		µG/L	2
CARBONATE AS CaCO ₃	1000 10000	8/24	0	12000	—	V	4087	1764		µG/L	2
CHEMICAL OXYGEN DEMAND	0 10000	13/16	4800.0	21000	—	V	4287	10048		µG/L	
CHLORIDE	200.0 100000	29/29	12000	530000	—	V	B207089	311351	63635	µG/L	1.2

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{99.99} Concentration	Units	PCOC
CYANIDE	5.00 100.0	2/22	1	5 6000	B	V	B207089	8	12	µG/L	
FLUORIDE	0 - 100.0	32/32	230.00	3400.0	-	-	4087	692	2024	µG/L	1
NITRATE/NITRITE	20.00 2800.0	32/35	20.00	72000	-	V	B206989	7714	55685	µG/L	1 2
ORTHOPHOSPHATE	10.00 50.00	12/21	6.000	150.00	-	JA	4287	30.14	53	µG/L	1 2
pH	0.10 0.10	3/3	7.6	7.73	-	Y	B207089	7.7		PH	
SILICA	400.0 400.0	10/10	2600.0	9000	-	-	4087	4460	35735	µG/L	
SPECIFIC CONDUCTIVITY	1.00 - 1.00	2/2	3105.2	3110	-	Y	B207089	3108		UMHOS/CM	
SULFATE	1000.00 - 100000	32/32	33000	19000000	-	-	B207089	1081886	613607	µG/L	1 2
TOTAL DISSOLVED SOLIDS	5000 14000	32/32	280000	5100000	-	V	B206989	1529688	1290550	µG/L	1 2
TOTAL ORGANIC CARBON	1000 5000	15/17	190.00	10500.0	-	Y	4087	4190		µG/L	
TOTAL SUSPENDED SOLIDS	4000 - 5000	30/32	4000	442000	-	V	4287	74484	1402588	µG/L	

All analytes are total analytes unless otherwise noted

Organic analytes with zero hits are not reported

Metal analytes with zero hits are reported

All radionuclide results are considered hits

The minimum result may be a hit or not a hit

The maximum detection may only be a hit

In calculating the mean one half of the detection limit is used for those results that are not hits

- 1 Analyte determined to be PCOC by hot measurement test
- 2 Analyte determined to be PCOC by inferential statistics test(s)
- 3 Analyte not considered a PCOC because it is a nutrient
- 4 All detected organic analytes are considered PCOCs unless eliminated by professional judgment
- 5 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples

Data Qualifiers

- data qualifier or validation field in database is blank
- B for inorganics reported value is < CRDL but > IDL (estimated value)
- B for organics analyte is also detected in blank, for common lab contaminants include as detection if blank result > 10 times detection limit for all other organics include if blank result > 5 times detection limit
- J for inorganics value > IDL but control sample analysis not within control limits (estimated value)

- J for organics MS data indicate presence of compound but below detection limit (estimated value)
- N for inorganics spiked sample recovery is not within control limits (estimated value)
- U for inorganics and organics analyte analyzed but not detected at the quantitation limit

Data Validation Codes

- data qualifier field in database is blank
- A acceptable result
- JA acceptable result (for estimated value)
- V valid result
- Y analytical results in validation process

Definitions

- CRDL contract-required detection limit
- IDL instrument detection limit
- PCOC potential contaminant of concern
- UTL_{99/99} upper tolerance interval of the 99th percentile at the 99-percent confidence level

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Table 2-12
Analytes Detected in LHSU Groundwater Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{95%} Concentration	Units	PCOC
METALS											
ALUMINUM	200 200	1/1	2490	2490	N*	JA	4187	2490	13788	µG/L	
ANTIMONY	60 60	1/1	28 1	28 1	B	JA	4187	28 1	1269	µG/L	
BARIUM	200 200	1/1	387	387	-	V	4187	387	1424	µG/L	
CALCIUM	5000 - 5000	1/1	108000	108000	-	V	4187	108000	127687	µG/L	2
CHROMIUM	10 10	1/1	60 7	60 7	-	V	4187	60 7	1210	µG/L	
COBALT	50 50	1/1	3 1	3 1	B	V	4187	3 1	1237	µG/L	
COPPER	25 25	1/1	16 9	16 9	B	V	4187	16 9	1338	µG/L	
IRON	100 100	1/1	2400	2400	*	JA	4187	2400	18339	µG/L	
LEAD	3 3	1/1	4 4	4 4	-	V	4187	4 4	22	µG/L	
LITHIUM	100 100	1/1	91 9	91 9	B	V	4187	91 9	150	µG/L	
MAGNESIUM	5000 5000	1/1	26200	26200	-	V	4187	26200	28140	µG/L	2
MANGANESE	15 15	1/1	121	121	-	V	4187	121	615	µG/L	
MOLYBDENUM	200 200	1/1	24	24	B	V	4187	24	1241	µG/L	
NICKEL	40 40	1/1	48 4	48 4	-	V	4187	48 4	1266	µG/L	
POTASSIUM	5000 5000	1/1	6220	6220	-	V	4187	6220	8801	µG/L	2
SELENIUM	5 5	1/1	3	3	B	V	4187	3	5	µG/L	
SODIUM	5000 5000	1/1	437000	437000	-	V	4187	437000	659404	µG/L	2
STRONTIUM	200 200	1/1	1470	1470	-	V	4187	1470	1725	µG/L	
VANADIUM	50 50	1/1	11 6	11 6	B	V	4187	11 6	1274	µG/L	
ZINC	20 20	1/1	52 6	52 6	E	JA	4187	52 6	1401	µG/L	
RADIONUCLIDES											
AMERICIUM 241	0.00377 - 0.01	4/4	0	0.00696	-	Y	53094	0.004	0.072	PC/L	

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Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{ase} Concentration	Units	PCOC
CESIUM 137	1 1	1/1	0.3585	0.3585	J	—	B207189	0.3585	1.05	PC/L	
GROSS ALPHA	1 1	1/1	8.4	8.4	—	V	0886	8.4	133	PC/L	
GROSS BETA	2.9 2.9	1/1	5.4	5.4	—	V	0886	5.4	110.7	PC/L	
PLUTONIUM-238	0.01 0.0119	3/3	0.00257	0.002145	J	—	B207189	0.00007		PC/L	
PLUTONIUM 239/240	0 0.01	4/4	0.0006231	0.01192	—	A	B207189	0.006		PC/L	
RADIUM 226	0.5 0.5	1/1	1.5	1.5	—	—	4187	1.5		PC/L	
TRITIUM	200 910	26/26	173	300	U	V	B207189	31	1779	PC/L	
URANIUM 233 234	0.14 0.14	1/1	3.24	3.24	—	A	4187	3.24		PC/L	
URANIUM 235	0.06 0.06	1/1	0.08	0.08	—	A	4187	0.08	0.27	PC/L	
URANIUM-238	0.13 0.13	1/1	1.2	1.2	—	A	4187	1.2		PC/L	

VOLATILE ORGANICS

ACETONE	10 - 100	3/39	4	10	B	—	B207189	8	12	µG/L	3.4
CHLOROBENZENE	0.2000 - 5	1/46	0.2	1	J	—	4187	2		µG/L	3.4
METHYLENE CHLORIDE	0.1000 5	13/46	0.1	16	—	V	0886	3	12	µG/L	1.3.4
TOLUENE	0.1000 - 5	3/46	0.1	2	J	A	0886	2		µG/L	3.4
TOTAL XYLENES	5 - 5	1/40	1	1	J	A	4187	2	4	µG/L	3.4

INDICATOR PARAMETERS

AMMONIA	30.0 100.0	2/4	100.0	513	—	Y	4187	170		µG/L	
BICARBONATE AS CaCO ₃	1000 10000	36/38	1000	180000	—	V	0886	116371		µG/L	
CARBONATE	1000 10000	2/8	1000	23000	—	V	0886	6000	17826	µG/L	1
CARBONATE AS CaCO ₃	1000 10000	19/30	0	220000	—	V	B207189	30122		µG/L	
CHEMICAL OXYGEN DEMAND	5000 10000	10/10	5000.00	37000	—	V	4187	14470		µG/L	
CHLORIDE	200.0 50000	36/36	12000	1100000	—	—	4187	572823	532358	µG/L	
FLUORIDE	100.0 100.0	37/37	300.0	1500.0	—	V	0886	792.4	2303	µG/L	
NITRATE/NITRITE	20.00 5000	35/38	20.00	2400.0	—	V	0886	1287	4180	µG/L	
NITRITE	20.00 5000	1/3	20.00	250.00	—	—	4187	920.00	4859	µG/L	

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background UTL _{95%} Concentration	Units	PCOC
ORTHOPHOSPHATE	10.00 - 50.00	2/13	10.00	80.00	-	-	4187	13.46	51	µG/L	1
pH		2/2	8.8	12	-	-	B207189	10		PH	
SILICA	400.0 - 400.0	15/15	2300.0	6200.0	-	-	0886	3460	12145	µG/L	
SODIUM FLUORIDE	100.0 - 100.0	1/1	650.00	650.00	-	V	4187	650.00		µG/L	
SODIUM SULFATE	10000 - 10000	1/1	53000	53000	-	V	4187	53000		µG/L	
SOLIDS, NONVOLATILE SUSPENDED	5000 - 5000	1/1	138000	138000	-	JA	B207189	138000		µG/L	
SPECIFIC CONDUCTIVITY	10 - 10	2/2	490	3300	-	Y	4187	1895		UMHOS/CM	
SULFATE	2000 - 10000	37/37	6000	79000	-	JA	B207189	27908	992074	µG/L	
TOTAL DISSOLVED SOLIDS	10000 - 14000	38/38	230000	2000000	-	V	4187	1241658	2059573	µG/L	
TOTAL ORGANIC CARBON	1000 - 5000	11/13	1000	4120.00	-	Y	0886	2105		µG/L	
TOTAL SUSPENDED SOLIDS	4000 - 5000	36/37	5000	450000	-	V	0886	137122	2956564	µG/L	

All analytes are total analytes unless otherwise noted
Organic analytes with zero hits are not reported
Metal analytes with zero hits are reported
All radionuclide results are considered hits
The minimum result may be a hit or not a hit
The maximum detection may only be a hit
In calculating the mean one-half of the detection limit is used for those results that are not hits

Note Because of the small number of site samples inferential statistics were not performed. Only the hot measurement test was used to compare site data to background data

- 1 Analyte determined to be PCOC by hot measurement test
- 2 Analyte not considered a PCOC because it is a nutrient
- 3 All detected organic analytes are considered PCOCs unless eliminated by professional judgment
- 4 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples

Data Qualifiers

- data qualifier or field validation field in database is blank
- * for inorganics duplicate analysis is not within control limits (estimated value)
- B for inorganics reported value is < CRDL but > IDL (estimated value)
- B for organics analyte is also detected in blank for common lab contaminants include as detection if blank result > 10 times detection limit for all other organics include if blank result > 5 times detection limit

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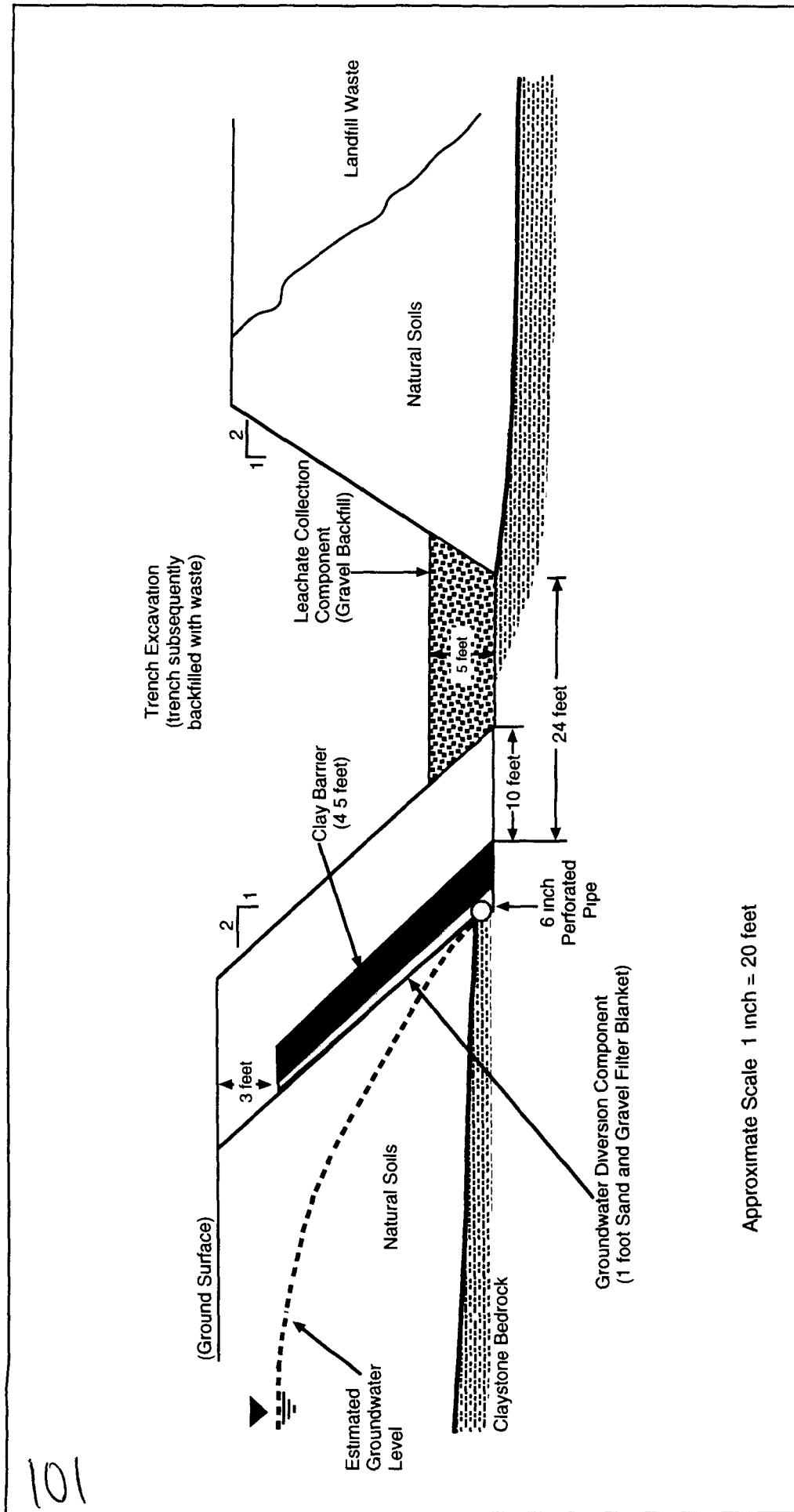
- E for inorganics value is an estimate due to interference (estimated value)
- J for inorganics value > IDL but control sample analysis not within control limits (estimated value)
- J for organics, data indicate presence of compound but below detection limit (estimated value)
- N for inorganics spiked sample recovery is not within control limits (estimated value)

Data Validation Codes

- data qualifier field in database is blank
- A acceptable result
- JA acceptable result (for estimated value)
- V valid result
- Y analytical results in validation process

Definitions

- CRDL contract required detection limit
- IDL instrument detection limit
- PCOC potential contaminant of concern
- UTL_{99.99} upper tolerance limit of the 99th percent confidence level



Approximate Scale 1 inch = 20 feet

Source Rockwell International 1988c

U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden Colorado

Design Section of Existing Groundwater Intercept and Leachate Collection System

IM/IRA DD Operable Unit No 7
July 1995 Figure 2-2

Age	Formation	Thickness (feet)
Quaternary	Rocky Flats Alluvium/ Colluvium	0-30
	Arapahoe Formation	0-20
Cretaceous	Laramie Formation	600-800
		upper interval 300-500
		lower interval 300
	Fox Hills Sandstone	90-140
	Pierre Shale and older units	

Clayey Sandy Gravels – reddish brown to yellowish brown matrix, grayish-orange to dark gray, poorly sorted, angular to subrounded, cobbles, coarse gravels, coarse sands and gravelly clays varying amounts of caliche

Claystones, Silty Claystones, and Sandstones – light to medium olive-gray with some dark olive-black claystone, silty claystone, and fine-grained sandstone, weathers yellowish orange to yellowish brown, a mappable, light to olive gray, medium- to coarse-grained, frosted sandstone to conglomeratic sandstone occurs locally at the base (Arapahoe marker bed or No. 1 sandstone)

Claystones, Silty Claystones, Clayey Sandstones, and Sandstones – kaolinitic, light to medium gray claystone and silty claystone and some dark gray to black carbonaceous claystone, thin (2') coal beds and thin discontinuous, very fine to medium-grained, moderately sorted sandstone intervals

Sandstones, Claystones, and Coals – light to medium gray, fine- to coarse-grained, moderately to well sorted, silty, immature quartzose sandstone with numerous claystones, and subbituminous coal beds and seams that range from 2' to 8' thick (Nos. 2 through 5 sandstones)

Sandstones – grayish orange to light gray, calcareous, fine-grained, subrounded glauconitic, friable sandstone

Source EG&G 1992a

U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden Colorado

Generalized Stratigraphic Section

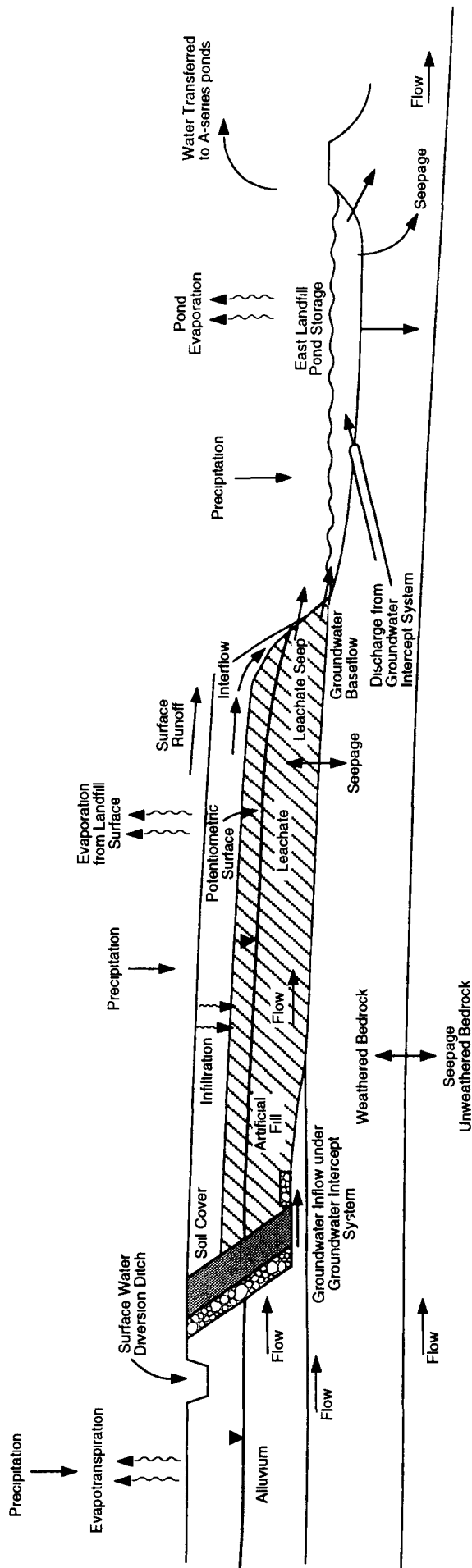
IM/IRA DD

Operable Unit No. 7

July 1995

Figure 2-3

Present Landfill Area Cross Section



U S DEPARTMENT OF ENERGY Rocky Flats Environmental Technology Site, Golden Colorado	
IM/IRA DD	Operable Unit No 7
July 1995	Figure 2-8

Conceptual Flow Model for the OU 7 Watershed

Not to scale

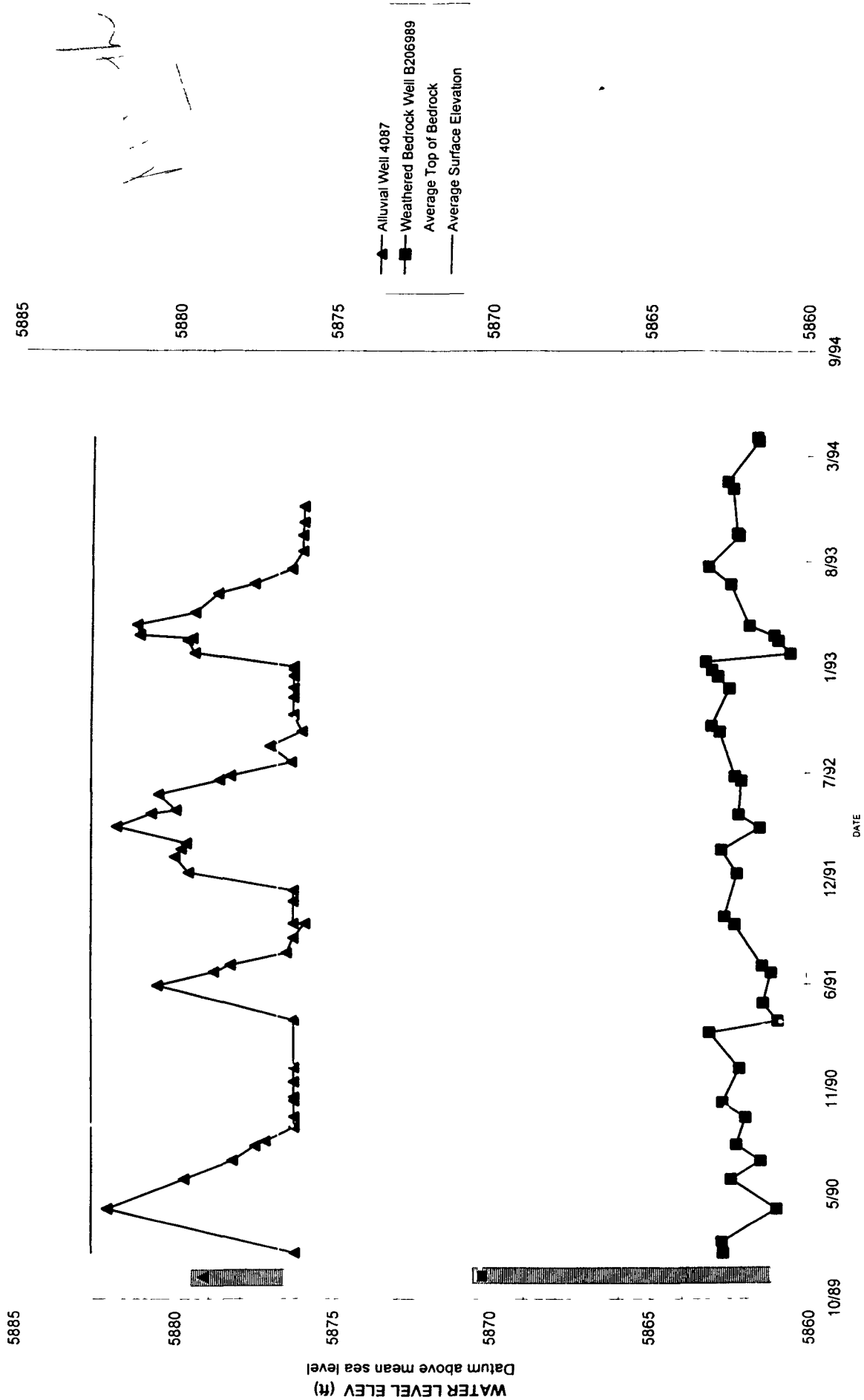
107

Figure 2-10



Figure 2-13

Well Cluster Hydrograph ²⁶ for Locations 4087 and B206989



EXPLANATION

● Sediment Sampling Location

◆ Surface Water Sampling Location

--- Intermittent Stream

=== Dirt Road

— Landfill Structures

Wetlands

Wet Meadow

Short Marsh

322 Mesic Mixed Grassland

Xeric Mixed Grassland

Disturbed Area -
Disturbed/Barren Land

500 Disturbed Area -
Developed Areas



0 Feet 120 240

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Site, Golden, Colorado

Environmental Technology
Surface Water
Distribution of Habitat
and Types
Sediment Sampling
Locations

Im/IRA DD
Closure Strategy

Operable Unit No 7

July
April 1995

Figure 2-14

3. Site Risks

3.1 Preliminary Remedial Action Objectives

In order to meet the overall objective of protecting human health and the environment under CERCLA (EPA 1991a), preliminary remedial action objectives (RAOs) were developed for each medium. RAOs are general descriptions of what the remedial action is expected to accomplish.

RAOs for presumptive remedy components of OU 7 (the landfill), which will remain a long-term waste management area, are specified in EPA guidance and include the following (EPA 1993a)

- prevent direct contact with landfill contents
- minimize infiltration and resulting contaminant leaching to groundwater
- control surface-water runoff and erosion
- control landfill gas (treat as needed)
- collect and treat leachate at the source (as needed)
- control groundwater at the source to contain the plume

RAOs for the other (non-presumptive remedy) components at OU 7 may include the following as needed

- remediate surface water in the East Landfill Pond (as needed)
- remediate sediments in the East Landfill Pond (as needed)
- remediate wetland areas (as needed)
- remediate surface soils in spray evaporation areas (as needed)
- remediate groundwater downgradient of the source (as needed)

In order to evaluate alternatives in terms of overall protection of human health and the environment, the manner in which site risks identified in the conceptual site model are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls was considered (EPA 1991a). The containment presumptive remedy will accomplish RAOs for the presumptive remedy components at OU 7 by addressing all pathways associated with the source. RAOs for the other components will be evaluated in terms of exposure pathways, risk, and compliance with ARARs in the following sections. The anticipated future land use for the area surrounding the landfill is open space. There are no plans to develop groundwater in the future for any use at OU 7, and existing information shows that there is only limited availability of groundwater downgradient of the landfill (see Section 2.3).

3.2 Conceptual Site Model for Defining Risks

Data collected during the Phase I and Phase II RFI/RIIs, presented in the OU 7 Final Work Plan (DOE 1994a) and summarized in Section 2, were used to develop a conceptual site model. The model identifies the suspected sources, contaminant release and transport mechanisms, exposure points or affected media, and exposure routes (Figure 3-1).

Contaminant sources include solid and liquid hazardous and nonhazardous wastes in the Present Landfill, soils in IHSS 203 where hazardous wastes were stored, and asbestos in the asbestos disposal areas. Mechanisms for contaminant releases include erosion of interim cover material exposing landfill contents directly, release of landfill contents by erosion and runoff, volatilization of landfill gas, leachate seep discharge to the East Landfill Pond, spray evaporation of pond water, and leaching of contaminants into the groundwater. Primary transport mechanisms are movement of landfill gas, movement with surface water runoff, movement with the leachate seep, and movement with groundwater. Spray evaporation activities ceased in 1994, therefore, continued releases are no longer occurring by this mechanism.

Contaminants in landfill gas may migrate into the atmosphere. After contaminants from the leachate seep or from runoff have entered the East Landfill Pond, they may remain suspended or dissolved in surface water, be deposited in sediment at the bottom of the pond, discharged to groundwater, or be taken up by plants or aquatic life in wetland areas. After contaminants in water from the pond have been sprayed onto the surrounding slopes and have infiltrated the soil, they may subsequently be leached out of the soil by runoff, infiltration/percolation, or be dispersed by the wind.

After contaminants have entered the groundwater, several migration pathways are possible. Groundwater in the UHSU could discharge to surface water in the East Landfill Pond. Groundwater in the UHSU could also migrate downgradient, discharge to surface water in No Name Gulch, migrate to the confluence of No Name Gulch and North Walnut Creek with surface water or groundwater, and eventually migrate offsite. This migration pathway is not likely because groundwater modeling has shown that migration is slowed considerably or possibly even stopped by the dam. Discharge from groundwater to surface water below the dam is not expected because the intermittent stream in No Name Gulch is a losing stream that discharges to groundwater. Groundwater in the UHSU could migrate slowly downgradient, remaining as groundwater. Groundwater in the UHSU could also seep down into the confining layers of the unweathered bedrock and eventually reach the sandstones of the LHSU. However, hydraulic conductivity values for the confining layer are low and downward seepage is minimal (Section 2.3).

VOCs detected in landfill leachate could be transported by seeps, surface-water runoff, or groundwater. During transport, VOCs in groundwater may be subject to adsorption, hydrolysis, and biological degradation under aerobic or anaerobic conditions. As stated above, discharge from groundwater to surface water below the dam is not expected and contaminants most likely migrate within groundwater.

Potential exposure pathways associated with OU 7 include ingestion and dermal contact with waste materials, inhalation of dust, and physical hazards from the source, inhalation and explosion of landfill gas, ingestion of leachate from the seep, and surface water and sediment from the East Landfill Pond, and inhalation, ingestion, dermal contact, and external irradiation of soils in spray evaporation areas. There are no potential exposure pathways associated with subsurface geologic materials or groundwater downgradient of the landfill. However, the risk associated with ingestion of groundwater from downgradient wells was evaluated for the purpose of defining the point of compliance.

Because the contents of the landfill, IHSS 203, and the asbestos disposal areas will be contained, the conceptual site model is most useful for identifying areas beyond the landfill that may pose a threat to human health or the environment. Risks posed by these media are evaluated below.

3.3 Evaluation of Risks

Baseline risk assessments evaluate the potential threat to human health and the environment in the absence of any remedial action and often provide the basis for determining if remedial action is necessary and the justification for performing remedial actions. Under the presumptive remedy approach, a quantitative baseline risk assessment is not necessary to evaluate if the containment remedy addresses pathways and contaminants of concern associated with the source. Rather, all potential exposure pathways can be identified using the conceptual site model and compared to the pathways addressed by the containment presumptive remedy (EPA 1993a). For pathways that are not addressed by the containment presumptive remedy, a focused or streamlined risk assessment was performed. The methodology for the focused risk assessment is described below.

3.3.1 Methodology to Determine if a Response Action is Necessary

Leachate resulting from land-disposed hazardous wastes classified by more than one waste code under RCRA Subpart D or from a mixture of wastes classified under RCRA Subparts C and D is F039 RCRA-listed waste contained in groundwater (6 CCR 1007-3, Part 261). The method used to determine the hazardous waste classification and resultant treatment standards for various environmental media at OU 7 is shown in Figure 3-2. The first step is to determine if land disposal of hazardous waste has

occurred. The second step is to ascertain if leachate exists by application of the "derived from" rule. The third step is to determine if multisource leachate (F039) exists. And, the fourth and final step is to determine if the "contained in" policy applies to these environmental media. If it does, the waste must meet standards or be remediated or treated to meet standards. Once standards are met, the media no longer "contains" listed waste.

Only leachate within the landfill is considered F039 RCRA-listed waste. Leachate that discharges at the seep, surface water in the East Landfill Pond, pond sediments, surface soils in spray evaporation areas, and groundwater downgradient of the landfill constitute leachate "contained in" environmental media. Therefore, risk-based analyses were performed to determine if these media pose a threat to human health or the environment.

Methods used to evaluate chemical data for samples collected from these environmental media are shown in Figure 3-3. The methodology uses PCOCs previously identified in site-to-background comparisons following EG&G guidance (EG&G 1994b) after professional judgment has been applied to streamline the list, and encompasses a focused risk assessment that includes a preliminary remediation goal (PRG) screen and risk calculations. The risk evaluation is used to determine if remediation of other (non-presumptive) media are required.

Land-use scenarios used for the PRG screen and the risk calculations were based on recommendations from the Future Land-Use Working Group and include an open-space scenario for landfill leachate, surface water, and soil, a residential scenario for sediment, and a future onsite office-worker scenario for groundwater. Although residential uses have been eliminated from the land-use plan (DOE 1995c), a residential scenario for exposure to sediment was selected as a bounding scenario. In addition, even though there are no potential exposure pathways associated with groundwater downgradient of the landfill, risks due to groundwater ingestion were calculated as a bounding scenario.

Sitewide PRGs were developed for use in Rocky Flats environmental remediation activities and are based on a target risk of $1E-06$ or a hazard index of 1. PRGs are included in Final Programmatic Risk-Based Preliminary Remediation Goals (DOE 1995c) and in the Draft Programmatic PRGs for Rocky Flats Plant--Open Space (DOE 1995d). The maximum detected concentration of each PCOC was compared to the PRG for that analyte. If the maximum concentration of an analyte was less than the PRG, the analyte was dropped from further consideration. If the maximum detected concentration of an analyte was greater than the PRG, the analyte was evaluated in the focused risk assessment. Maximum concentrations are used for the PRG screen to provide a conservative approach that is consistent with the CDPHE risk-based

conservative screen (CDPHE/EPA/DOE 1994), performed for baseline risk assessments at Rocky Flats

None of the PCOCs in landfill leachate, surface water, or sediment failed the PRG screen, therefore, PCOCs in these media were dropped from further consideration. Risks were estimated for PCOCs in surface soil and groundwater that failed the PRG screen using the 95 percent upper confidence limit of the mean concentration (UCL₉₅). Risks were calculated for incidental ingestion, particulate inhalation, and external irradiation from surface soil by an open-space receptor, and for groundwater ingestion by a future onsite office worker. Risks were not calculated for dermal exposure to surface soils because the OU 7 surface-soil PCOCs included only metals and radionuclides and, in accordance with EPA guidance, dermal exposure to metals and radionuclides cannot be quantified (EPA 1989a). Site-specific exposure factors and open-space exposure parameters were used to calculate risks (DOE 1995e, DOE 1995f). Environmental media with carcinogenic risks that fall below or within the EPA acceptable risk range of 1E-04 to 1E-06 and noncarcinogenic risks that are below the hazard index of 1 do not require a response action (EPA 1993a).

A screening-level ecological risk assessment was performed to determine if PCOCs in leachate, surface water, and sediment present an unacceptable toxicological risk to aquatic life and wildlife. Exposure and toxicity of PCOCs in sediments and pond water to aquatic life are used to determine if conditions in the pond are adequate to support a functional aquatic habitat. Potential toxicity of leachate, pond water, and sediment to aquatic-feeding avian and mammalian wildlife species (mallards and raccoons) and to non-aquatic wildlife species (mule deer, coyotes, and Preble's meadow jumping mouse) was evaluated.

Ecological exposures and risk estimations are based on the same data used to characterize the nature and extent of contamination (Section 2.5) and the potential human health risks presented below. Risks were characterized by comparing chemical concentrations in abiotic media to literature-based benchmarks to determine if PCOCs are present in concentrations that could be toxic to aquatic life or wildlife (DOE 1995b, DOE 1995g). Conservative assumptions were adopted in developing benchmarks and estimating exposures to minimize the chance of underestimating risk. Results of the ecological risk assessment are summarized below and presented in detail in Appendix D.

3.3.2 Present Landfill, IHSS 203, and Asbestos Disposal Areas

A quantitative risk assessment is not necessary for the source area. Potential exposure to soils and waste material in the Present Landfill, IHSS 203, and asbestos disposal areas from direct contact, volatilization, and/or wind will be addressed by the

presumptive remedy for source containment (Figure 3-4) The proposed landfill cover will prevent exposure to source materials and the type of cap will be determined by closure ARARs Because the continued effectiveness of the containment remedy depends on the integrity of the containment system, it is likely that institutional controls will be necessary to restrict future activities at the landfill after construction of the cap In accordance with EPA guidance, it is not necessary or appropriate to estimate the risk associated with future residential land use because such use would be incompatible with the need to maintain the integrity of the containment system (EPA 1993a)

3 3 3 Landfill Gas

A quantitative risk assessment is not necessary for landfill gas Potential exposure to landfill gas will be addressed by the presumptive remedy for gas control (Figure 3-5) The proposed landfill cover will include a gas-venting layer Gas emissions will be contingent upon air-emission ARARs

3 3 4 Landfill Leachate at the Seep

A quantitative risk assessment is not necessary for leachate in the source area Potential exposure to landfill leachate will be addressed by the presumptive remedy for source containment (Figure 3-6) The proposed landfill cap will cover the seep area and prevent exposure to leachate, reduce contaminant leaching to groundwater, and ultimately reduce leachate generation and migration In addition, leachate will be collected and treated at the seep as an accelerated action for OU 7 before closure However, a focused risk assessment was performed as a conservative measure to evaluate the potential risk from ingestion of leachate

Potential human receptors are open-space recreational users A PRG screen was performed for landfill leachate (SW097) using an open-space exposure scenario (DOE 1995d) Results of the PRG screen are presented in Table 3-1 None of the 37 PCOCs from Section 2 5 3, Nature and Extent of Contamination in Landfill Leachate at the Seep, exceeded the PRGs for an open-space recreational user Therefore, there is no risk to human health from incidental ingestion of leachate at the seep

Potential ecological receptors include terrestrial and avian wildlife A screening-level ecological risk assessment was performed to determine if PCOCs in leachate from the seep present an unacceptable toxicological risk to aquatic life and wildlife (Appendix D) Baseline risk estimates were based on the conservative assumption that receptors spend all of their time at the East Landfill Pond

Under these conditions, the hazard index (HI) was greater than 1 for mallards, raccoons, and coyotes (mallard HI = 50, raccoon HI = 3, mule deer HI = 0 08, coyote HI = 3, Preble's meadow jumping mouse HI = 0 02) Risk to mallards is from potential

exposure to naphthalene, 2-methyl-naphthalene, bis(2-ethylhexyl)phthalate, and phenanthrene. Risk to raccoons is from potential exposure to naphthalene, 2-methyl-naphthalene, bis(2-ethylhexyl)phthalate, and total xylenes. Risk to coyotes is from potential exposure to naphthalene, 2-methyl-naphthalene, phenanthrene, and barium. Hazard quotients for individual PCOCs and hazard indices are estimated for risks associated with no-observed-adverse-effects levels (NOAELs); risk is lower for exceeding lowest-observed-adverse-effects levels (LOAELs). Sources of uncertainty for ecological risk are the actual bioavailability of PCOCs, assumptions about frequency and duration of exposures, and the importance of the East Landfill Pond as a habitat resource. Because it was assumed that mallards, raccoons, and coyotes spend all of their time at the pond and drink exclusively from the seep, risks were probably overestimated.

3.3.5 Surface Water in the East Landfill Pond

A focused or streamlined risk assessment is necessary for surface water in the East Landfill Pond because surface water is not a component of the presumptive remedy. Potential exposure pathways identified in the conceptual site model can be used to determine affected media, exposure routes, and potential receptors (Figure 3-7). After contaminants from the leachate seep or from runoff have entered the East Landfill Pond, they may remain suspended or dissolved in surface water, be deposited in sediment at the bottom of the pond, discharged to groundwater, or be taken up by plants or aquatic life in wetland areas. The potential exposure pathway evaluated is incidental ingestion of surface water in the East Landfill Pond.

Potential human receptors include open-space recreational users. A PRG screen was performed for pond water (SW098) using an open-space exposure scenario (DOE 1995b). Results of the PRG screen are presented in Table 3-2. None of the 15 PCOCs from Section 2.5.4, Nature and Extent of Contamination in Surface Water in the East Landfill Pond, exceeded the PRGs for an open-space receptor, and, therefore, no risk assessment was performed. There is no risk to human health from incidental ingestion of surface water from the East Landfill Pond.

Potential ecological receptors include aquatic life and terrestrial and avian wildlife. A screening-level ecological risk assessment was performed to determine if PCOCs in pond water present an unacceptable toxicological risk to aquatic life and wildlife (Appendix D). None of the surface water PCOCs exceeded state water quality standards or risk-based benchmarks. The cumulative risk, expressed as the hazard index, also did not exceed 1. These data are consistent with whole effluent toxicity tests performed on water samples from the pond. Results of the literature-based toxicity screen, laboratory toxicity testing, and the preliminary risk calculation indicate that pond water represents negligible risk to aquatic life. Baseline risk estimates were

based on the conservative assumption that receptors spend all of their time at the East Landfill Pond

Under these conditions, the hazard index was greater than 1 only for mallards (mallard HI = 10, raccoon HI = 0.3, mule deer HI = 0.01, coyote HI = 0.03, Preble's meadow jumping mouse HI = 0.03). Risk to mallards is from potential exposure to bis(2-ethylhexyl)phthalate and di-n-butyl phthalate. Sources of uncertainty for ecological risk are the actual bioavailability of PCOCs, assumptions about frequency and duration of exposures, and the importance of the East Landfill Pond as a habitat resource. Because it was assumed that mallards spend all of their time at the East Landfill Pond, risk to mallards was probably overestimated.

The East Landfill Pond includes approximately 3 percent of the open-water habitat and 6 percent of the available shoreline habitat at Rocky Flats, the adjacent wetland represents approximately 1.6 percent of the total wetland areas at Rocky Flats (COE 1994). The screening-level ecological risk assessment did not include risks to wetland vegetation. It was assumed that wetland areas will be mitigated as needed.

Since the East Landfill Pond was constructed only 20 years ago, it is probably not a historically important component of the local ecosystem (Appendix D). The pond apparently does not contain fish or crayfish populations. Without a complex aquatic food web that includes upper-level aquatic consumers, the pond is a limited resource for aquatic-feeding wildlife. The lack of upper-level aquatic consumers may help attenuate the transfer of contaminants via food web interactions (Rasmussen et al 1990). The pond area has been identified as potential habitat for one federal candidate species, Preble's meadow jumping mouse (DOE 1995b), but their occurrence there has not been confirmed. It is possible that other state- or federally-protected species may use the pond area occasionally (DOE 1995g), but the resources at the East Landfill Pond are not critical to any of them.

3.3.6 Sediments in the East Landfill Pond

A focused or streamlined risk assessment for sediment in the East Landfill Pond is necessary because pond sediment is not a component of the presumptive remedy. Potential exposure pathways identified in the conceptual site model can be used to determine affected media, exposure routes, and potential receptors (Figure 3-7). After contaminants from the leachate seep or from runoff have entered the East Landfill Pond, they may remain suspended or dissolved in surface water, be deposited in sediment at the bottom of the pond, discharged to groundwater, or be taken up by plants or aquatic life in wetland areas. The potential exposure pathway evaluated is incidental ingestion of sediment from the East Landfill Pond. Potential human receptors are

residential recreational users, which occupy the site more frequently than open-space recreational users, but less frequently than residents

A PRG screen was performed for pond sediment using a residential recreational-user exposure scenario. Sediment PRGs for the residential recreational exposure scenario were not developed for the sitewide PRG document (DOE 1995a). Rather, the exposure factors were developed and discussed in correspondence between DOE and EG&G (EG&G 1994c). The PRGs are based on a target risk of $1E-06$ and a hazard index of 1. Results of the PRG screen are presented in Table 3-3. None of the 33 PCOCs from Section 2.5.5, Nature and Extent of Contamination in Sediments from the East Landfill Pond, exceeded the PRGs for a residential recreational user, and, therefore, no risk assessment was performed. There is no risk to human health from incidental ingestion of sediment from the East Landfill Pond.

Potential ecological receptors include aquatic life and terrestrial and avian wildlife. A screening-level ecological risk assessment was performed to determine if PCOCs in sediment present an unacceptable toxicological risk to aquatic life and wildlife (Appendix D). Baseline risk estimates were based on the conservative assumption that receptors spend all of their time at the East Landfill Pond. The hazard index for exposure of aquatic life to sediments was greater than 1,100. PCOCs contributing most to risk estimates were fluorene, anthracene, chrysene, benzo(b)fluoranthene, and barium. Results of toxicity tests performed on pond sediments are not consistent with these results. Sediment samples used in the toxicity tests were collected from the same locations as samples collected for chemical analyses.

Preliminary risk calculations based on exposure estimations appear to overestimate risks to aquatic life. Based on these calculations, risk of toxicity to sediment-associated organisms appears to be high, but results of site-specific surface water and sediment toxicity tests indicate no toxicity. In addition, many of the species present in sediment samples are moderately tolerant of polluted sediments suggesting that conditions in the pond are not as toxic as indicated by the hazard quotients. Risk to aquatic life appears to be minimal (Appendix D).

Under these conditions, the hazard index was greater than 1 for raccoons, mule deer, coyotes, and Preble's meadow jumping mouse (mallard HI = 0.8, raccoon HI = 6, mule deer HI = 3, coyote HI = 4, Preble's meadow jumping mouse HI = 3). Risk to raccoons is from potential exposure to aluminum, vanadium, and arsenic. Risk to mule deer, coyotes, and Preble's meadow jumping mice is from potential exposure to aluminum (Appendix D). Sources of uncertainty for ecological risk are the actual bioavailability of PCOCs, assumptions about frequency and duration of exposures, and the importance of the East Landfill Pond as a habitat resource. Although there is risk to avian and

terrestrial wildlife, it is unlikely that receptors spend all of their time at the East Landfill Pond, and therefore, the risk is probably overestimated

3.3.7 Surface Soils in Spray Evaporation Areas

A focused risk assessment for surface soils in spray evaporation areas is necessary because surface soils are not a component of the presumptive remedy. Potential exposure pathways identified in the conceptual site model can be used to determine affected media, exposure routes, and potential receptors (Figure 3-8). After contaminants in water from the pond have been sprayed onto the surrounding slopes and have infiltrated the soil, they subsequently may be leached out of the soil by runoff or infiltration/percolation, or dispersed by the wind. Potential exposure pathways include particulate inhalation, ingestion, dermal contact, and external irradiation.

Potential human receptors are open-space recreational users. Risks were calculated for PCOCs identified in the combined 0- to 2-inch and 0- to 10-inch soil horizons around the East Landfill Pond. Samples were collected from the landfill eastward across the spray evaporation areas and surrounding slopes and downwind below the dam. A PRG screen was performed for surface soil using an open-space scenario (DOE 1995d). Results of the PRG screen are presented in Table 3-4. The UCL₉₅ for each PCOC that failed the PRG screen was used to estimate the risks of incidental ingestion, particulate inhalation, and external irradiation with surface soil for an open-space recreational user. Risks were not calculated for dermal exposure to surface soils because the OU 7 surface soil PCOCs included only metals and radionuclides and, in accordance with EPA guidance, dermal exposure to metals and radionuclides cannot be quantified (EPA 1989a).

The methodology used to evaluate the risks of exposure to surface soil was taken from Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A (EPA 1989a) and Part B (EPA 1991b). The open-space scenario assumes that a recreational user visits the open-space area 25 times per year. Exposure parameters for each pathway are presented in Tables 3-5, 3-6, and 3-7 (DOE 1995f). Intake factors were calculated using the equations listed below.

Incidental Ingestion

$$\text{Chemical Intake Factor (mg/kg-day)} = \frac{\text{IR} \times \text{ME} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

$$\text{Radionuclide Intake Factor (mg)} = \text{IR} \times \text{ME} \times \text{EF} \times \text{ED}$$

where IR = ingestion rate
 ME = matrix effect in the GI tract (absorption factor)
 EF = exposure frequency
 ED = exposure duration
 BW = body weight
 AT = averaging time

Particulate Inhalation

$$\text{Chemical Intake Factor (1/day)} = \frac{\text{IR} \times 1/\text{PEF} \times \text{RF} \times \text{DF} \times \text{ET} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

$$\text{Radionuclide Intake Factor (kg)} = \text{IR} \times 1/\text{PEF} \times \text{RF} \times \text{DF} \times \text{ET} \times \text{EF} \times \text{ED}$$

where IR = inhalation rate
 PEF = particulate emission factor (standard default [EPA 1991b])
 RF = respirable fraction (PM-10)
 DF = respiratory deposition factor
 ET = exposure time
 EF = exposure frequency
 ED = exposure duration
 BW = body weight
 AT = averaging time

External Irradiation

$$\text{Intake Factor (years)} = \text{ET} \times \text{SF} \times \text{EF} \times \text{ED}$$

where ET = gamma exposure time factor
 SF = gamma shielding factor
 EF = exposure frequency ratio
 ED = exposure duration

Cancer slope factors and reference doses were taken from Health Effects Assessment Summary Tables (HEAST) (EPA 1994a) and Final Programmatic Risk-Based Preliminary Remediation Goals (DOE 1995c), which includes a compilation of current toxicity factor information. Risks were calculated for ingestion, particulate inhalation,

and external irradiation. Results of the risk calculations are presented in Tables 3-8, 3-9, and 3-10. Carcinogenic risk is within the acceptable risk range for incidental ingestion by a child ($4E-07$), incidental ingestion by an adult ($2E-07$), particulate inhalation ($2E-11$), and external irradiation ($6E-09$). Noncarcinogenic risk (hazard index) is below 1 for incidental ingestion by a child ($HI = 0.008$) and incidental ingestion by an adult ($HI = 0.0009$). These results indicate that there is no risk to human health from incidental ingestion, particulate inhalation, or external irradiation from surface soils in spray evaporation areas.

3.3.8 Groundwater Downgradient of the Landfill

A focused risk assessment for groundwater downgradient of the landfill is necessary because groundwater that has migrated away from the source area is not a component of the presumptive remedy. After contaminants have entered the groundwater, they most likely migrate downgradient through the UHSU to the confluence of No Name Gulch and North Walnut Creek and eventually migrate offsite. Groundwater modeling has shown that migration is slowed considerably or possibly even stopped by the dam. Discharge from groundwater to surface water downgradient of the dam is not expected. Discharge does occur to the pond. The intermittent stream in No Name Gulch is a losing stream that discharges to groundwater. During transport, contaminants in groundwater may be subject to adsorption, hydrolysis, and biological degradation under aerobic or anaerobic conditions.

There are no potential exposure pathways associated with groundwater downgradient of the landfill, however, for the purpose of evaluating potential risks, ingestion of groundwater from downgradient wells was used (Figure 3-9). Potential human receptors are future onsite office workers. Risks were calculated for PCOCs identified in UHSU groundwater from two populations: (1) wells in the vicinity of the East Landfill Pond upgradient of the dam and (2) wells downgradient of the dam. These populations were evaluated separately to determine the downgradient limit of contamination. In the event that groundwater collection and treatment were needed, the system could be designed to collect only contaminated groundwater instead of all groundwater downgradient of the landfill.

A PRG screen was performed for groundwater using a future onsite office-worker scenario. The maximum detected concentration of each PCOC was compared to the PRG for that analyte (DOE 1995c). Results of the PRG screen are presented in Table 3-11. If the maximum detected concentration or activity of an analyte was less than the PRG, the analyte was dropped from further consideration. If the maximum detected concentration of an analyte was greater than the PRG, the analyte was evaluated in the risk assessment. A focused human health risk assessment was performed for groundwater in both populations using a future onsite office-worker groundwater

ingestion scenario The UCL_{95} for each PCOC that failed the PRG screen was used to calculate the risks of groundwater ingestion

The methodology used to assess risks at OU 7 was taken from Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (EPA 1989a) The future onsite office-worker scenario assumes that a worker ingests 1 liter of water per day for 250 days per year Exposure parameters are presented in Table 3-12 (DOE 1995e) Intake factors were calculated using the equations listed below

Groundwater Ingestion

$$\text{Chemical Intake Factor (L/kg-day)} = \frac{IR \times FI \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake Factor (liters)} = IR \times FI \times EF \times ED$$

where IR = ingestion rate
 FI = fraction ingested from the contaminated source
 EF = exposure frequency
 ED = exposure duration
 BW = body weight
 AT = averaging time

Oral cancer slope factors and oral reference doses were taken from HEAST (EPA 1994a) and Final Programmatic Risk-Based Preliminary Remediation Goals (DOE 1995c), which includes a compilation of current toxicity factor information Results of the risk calculations are presented in Table 3-13

The carcinogenic risk from ingestion of UHSU groundwater in the vicinity of the pond upgradient of the dam is within the acceptable risk range of $1E-04$ to $1E-06$ ($1E-05$), however, the noncarcinogenic risk is above the acceptable risk or hazard index of 1 ($HI = 3$) The primary contributor to noncarcinogenic risk is selenium ($HI = 1.5$) The risks from ingestion of UHSU groundwater downgradient of the dam are within the acceptable risk range (carcinogenic risk less than $1E-06$, noncarcinogenic risk, $HI = 0.2$) Therefore, there is no risk to future onsite office workers from ingestion of UHSU groundwater downgradient of the dam There is some risk associated with ingestion of UHSU groundwater in the vicinity of the East Landfill Pond upgradient of the dam However, the potential exposure pathway associated with groundwater downgradient of the landfill is incomplete (no one will be ingesting groundwater from wells)

3.4 Compliance With ARARs

Pursuant to the Interagency Agreement, onsite remedial actions at OU 7 must comply with all applicable RCRA and CHWA requirements, and must also address CERCLA requirements (DOE 1991a). CERCLA Section 121(d), as amended by SARA, requires that, at a minimum, any remedial or removal action achieve overall protection of human health and the environment and comply with ARARs. Laws included under this ARARs umbrella include all federal environmental laws and state standards more stringent than their federal counterpart. State regulations promulgated under federally authorized programs are considered federal requirements (EPA 1990a). Because Rocky Flats is a DOE facility, DOE orders apply with the same force as applicable federal regulations (EPA 1989b).

Laws and regulations identified as ARARs are either applicable or relevant and appropriate. Applicable requirements are those "cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental laws, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (40 CFR Section 300.5). Relevant and appropriate requirements are defined as "those standards that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site (40 CFR Section 300.5)".

ARARs are used to create a framework for determining the health and risk-based limits for remedial action and to develop remedial alternatives. Ultimately, it is necessary to demonstrate that the final remedy addresses all pathways and contaminants of concern, not just those that trigger the need for remedial action (EPA 1991a). Onsite actions must comply only with the substantive aspects of ARARs; offsite activities must adhere to both substantive and administrative requirements. Substantive requirements include cleanup standards or levels of control; administrative requirements prescribe methods and procedures such as fees, permitting, inspection, and reporting requirements. As activities at OU 7 do not have offsite consequences, no administrative requirements are identified.

There are three types of ARARs: chemical-specific, action-specific, and location-specific. This division, prescribed by EPA, is a convenient way to categorize regulations in a way that ties them to the remedial process. The following sections identify potential ARARs for OU 7 by type of requirement. In addition, guidance to be considered (TBC) are identified where appropriate. TBCs are advisories, criteria, or guidance that may be useful in developing CERCLA remedies (40 CFR Section

300 400[g][3]) TBCs may be used to supplement promulgated standards when the meaning of those standards is ambiguous or when they do not address a particular situation

3 4 1 Potential Chemical-Specific ARARs

Chemical-specific ARARs identify acceptable limits for defining an amount or concentration of a chemical that may be present in the environment. These standards usually take the form of health-based or risk-based numerical limitations that restrict ambient concentrations of various chemical substances above a threshold level. All applicable or relevant and appropriate federal chemical-specific standards (e.g., maximum contaminant levels [MCLs], state groundwater enforcement standards, Land Disposal Restrictions [LDR] universal treatment standards) must be complied with when determining appropriate cleanup levels for landfill leachate, surface water in the East Landfill Pond, and groundwater downgradient of the landfill. State ARARs must also be complied with if they are more stringent than federal standards. For chemicals that do not have any associated federal or state potential ARARs, the practical quantitation limit (PQL), cited in the regulations, or ten times the EPA Contract Laboratory Program detection limit when no PQL is cited, is proposed. Table 3-14 presents potential chemical-specific ARARs for surface water. Table 3-15 presents potential chemical-specific ARARs for groundwater.

3 4 1 1 *Landfill Leachate at the Seep*

Mean concentrations of all analytes detected in landfill leachate at the seep were compared to the potential chemical-specific ARARs for surface water. Mean concentrations of four metals (beryllium, cobalt, manganese, and zinc), two SVOCs (2-methylnaphthalene, naphthalene), and seven VOCs (1,1-dichloroethane, 1,2-dichloroethene, chloroethane, methylene chloride, tetrachloroethane, vinyl acetate, and vinyl chloride) exceed potential ARARs (Table 3-16). Of these, the maximum detections of beryllium and tetrachloroethane are less than their respective ARARs, however, the mean exceeds the ARAR because one-half the detection limit was used for non-detects in calculating the mean result and the detection limits vary and can be quite high. Vinyl acetate was detected in only one of 19 samples, and although this detection exceeds the ARAR, the low detection frequency suggests that this detection is an outlier and is not representative of landfill leachate. The maximum detection of methylene chloride is from 1990. These data were never validated and are "B" qualified, indicating that they were detected in the laboratory blank. These data are not appropriate for an ARARs comparison, and therefore, beryllium, tetrachloroethane, vinyl acetate, and methylene chloride are not considered further.

Nine analytes actually exceed ARARs in landfill leachate, they are cobalt, manganese, zinc, 2-methylnaphthalene, naphthalene, 1,1-dichloroethane, 1,2-dichloroethene, chloroethane, and vinyl chloride

3 4 1 2 *Surface Water in the East Landfill Pond*

Mean concentrations of all analytes detected in surface water in the East Landfill Pond were compared to the potential chemical-specific ARARs for surface water. Mean concentrations of one VOC (vinyl acetate) exceeds potential ARARs (Table 3-17). Vinyl acetate was detected in only one of 19 samples, and although this detection exceeds the ARAR, the low detection frequency suggests that this detection is an outlier and is not representative of surface water in the pond.

Surface water in the East Landfill Pond meets potential ARARs.

3 4 1 3 *Groundwater Downgradient of the Landfill*

Mean concentrations of all analytes detected in UHSU groundwater in individual wells downgradient of the landfill (in the vicinity of the pond and downgradient of the dam) were compared to the potential chemical-specific ARARs for groundwater. Mean concentrations of one metal (selenium), five VOCs (1,1-dichloroethane, benzene, methylene chloride, carbon tetrachloride and tetrachloroethene), and four water quality parameters (chloride, fluoride, nitrate/nitrite, and sulfate) exceed potential ARARs (Table 3-18).

Of these, the maximum detections of 1,1-dichloroethane, benzene, and tetrachloroethene are less than their respective ARARs, however, the mean exceeds the ARAR because one-half the detection limit was used for non-detects in calculating the mean result. Carbon tetrachloride was detected in two of 18 samples and only one of these detections exceeds the ARAR, the low detection frequency suggests that this detection is an outlier and is not representative of contaminants from the landfill source. Fluoride was detected in five samples in only one well, only one of the detections exceeds ARARs. The low detection frequency and the limited spatial extent of fluoride suggests that this detection is an outlier and is not representative of contaminants from the landfill. Methylene chloride is a common laboratory contaminant and was often detected in groundwater samples from sitewide background wells. Many of the detections were also from 1990. These data were never validated and are "B" qualified by the laboratory indicating that they were detected in the laboratory blank. These data are not appropriate for an ARARs comparison, and therefore, carbon tetrachloride, fluoride, and methylene chloride are not considered further.

Four analytes actually exceed ARARs in UHSU groundwater downgradient of the landfill, they are selenium, chloride, nitrate/nitrite, and sulfate. Selenium exceeds ARARs only in UHSU groundwater in the vicinity of the pond. Chloride, nitrate/nitrite, and sulfate exceed ARARs in UHSU groundwater in the vicinity of the pond and downgradient of the dam.

Three-dimensional contaminant-transport modeling was performed using an analytical solution developed by Domenico and Robbins (1985) and coded into the TPLUME model (Golder and Associates 1989). The input parameters and Surfer plots of outputs are presented in Appendix E. Model simulations were performed for chloride, selenium, and sulfate in surficial materials and for chloride, nitrate/nitrite, selenium, and sulfate in weathered bedrock.

For weathered bedrock, a sensitivity analysis on hydraulic conductivity was performed. Using the geometric mean hydraulic conductivity for weathered bedrock measured at OU 7 (2.3×10^{-6} cm/sec), all of the modeled contaminants exhibited minimal movement (Appendix E, Figures E8-E11). At this hydraulic conductivity, transport is controlled by diffusion. The UCL₉₅ of sitewide hydraulic conductivity values for weathered bedrock (5.6×10^{-5} cm/sec) was used in another set of simulations. These simulations exhibited more contaminant movement than the initial simulations, but none of the simulated contaminant plumes reached downgradient well 53194 (Appendix E, Figures E12-E15). Based on these simulations and on the flow regime in the weathered bedrock described in Section 2.3, the weathered bedrock pathway is not considered to be complete with respect to human or environmental receptors.

For surficial materials, the contaminant modeling showed that ARARs would be exceeded for selenium and sulfate at downgradient well 53194 at time equals 30 years. However, there are several reasons why these modeling results are overly conservative:

- **Constant source versus declining source assumption.** The TPLUME model assumes a constant source of contamination over the entire period of the simulation. Actual conditions at OU 7 indicate a declining source(s). If the landfill mass is the source of contaminants, the proposed cap and slurry wall (to be performed as a maintenance action) will reduce groundwater flow through the landfill and contaminant transport out of the landfill. For selenium, the source is suspected to be naturally occurring selenium released from the soil matrix because of conditions created by the spray evaporation of pond water or by the burial of sludges in IHSSs 166.1 and 166.3. The spray evaporation of pond water is considered the more likely source. Since the spray evaporation ended in 1994, this source should be reduced over time. For sulfate and nitrate/nitrite, the source is suspected to be either the buried sludges in IHSSs 166.1 and 166.3 or naturally occurring sulfate and nitrate released from the soil matrix as a result of conditions created by sludge.

burial While the existing nitrate/nitrite data do not show any temporal trends, the sulfate data show a slight but distinct decrease in concentrations over time

- Use of weathered-bedrock concentrations as source terms for surficial-materials modeling The TPLUME simulations for selenium and sulfate used weathered-bedrock concentrations as source terms for surficial-materials modeling because of data gaps for surficial materials This assumption is excessively conservative The measured potentiometric surfaces show a strong downward hydraulic gradient between the surficial materials and weathered bedrock in the vicinity of the dam with head differences of over 20 feet The measured concentrations of selenium and sulfate in surficial materials are much lower than the measured concentrations in the weathered bedrock
- Effect of the East Landfill Pond dam as a barrier to contaminant migration The TPLUME model assumes homogeneous, isotropic conditions and cannot account for hydraulic barriers As a result, the model does not take into account the effect of the dam as a barrier to contaminant migration As described in Sections 2.3 and 2.5 and Appendix C, the dam has proven to be a significant barrier to groundwater flow and contaminant migration in surficial materials

Based on the flow modeling and particle tracking in Appendix C and the contaminant-transport modeling in Appendix E, contaminant migration down No Name Gulch is expected to be minimal The wells at 52894, 4287, and 53194 will be adequate to monitor groundwater quality downgradient of the landfill Exceedance of ARARs at these wells is not expected The carcinogenic risk levels associated with the ingestion of groundwater by onsite office workers is less than $1E-06$ The noncarcinogenic risk is above the acceptable risk or hazard index of 1 (HI - 3) However, the exposure pathway associated with the UHSU groundwater downgradient of the landfill is incomplete This risk should stay in the acceptable range over the 30-year post-closure monitoring period As the landfill cap and slurry wall reduce leachate generation and migration, the water quality in the monitoring wells should improve over time

Wells downgradient of the dam that meet potential ARARs for UHSU groundwater include 4287, 52894, and 53194 These wells are proposed as downgradient wells for the post-closure groundwater monitoring system (6 CCR 1007-3, Section 265.90[a]), discussed under action-specific ARARs Samples collected from these wells are representative of groundwater quality downgradient of the landfill and the wells are capable of detecting groundwater contamination

3.4.2 Potential Location-Specific ARARs

Location-specific ARARs identify requirements that apply because the site has a special quality related to geography or the presence of a protected resource These requirements may limit the remedial action that may be implemented or create the need

for more stringent remedial efforts. Potential location-specific ARARs for OU 7 are presented in Table 3-19. Location-specific ARARs most pertinent to OU 7 concern wetlands, floodplains, and endangered species. Also of concern are historic, natural, cultural, or archaeological resources.

Remedial actions at OU 7 will have to be implemented in order to minimize the destruction, loss, or degradation of wetlands (40 CFR 6302[a]). As discussed in Section 2.4.3, wetlands have been designated along the shoreline of the East Landfill Pond by the U.S. Army Corps of Engineers (COE 1994). The wetland composes about 1.6 percent of the total wetlands at Rocky Flats. The loss of wetland areas that fall under the proposed footprint of the landfill cover and injury to remaining wetland areas will be mitigated as needed. The Clean Water Act Section 404 requires a permit for actions to dispose of dredge and fill material in waters of the United States. Because the East Landfill Pond and pond margins have been designated as wetlands, they are considered waters of the United States under the Clean Water Act. Remedial actions will likely impact the pond, consequently, the Clean Water Act Section 404 permitting requirements and Executive Order 11990 have been identified as potential ARARs and must be complied with. Only the substantive provisions of these ARARs must be complied with.

The remedial action is not required to comply with the Floodplain Environmental Review Requirements in 10 CFR 1022, because the floodplains at Rocky Flats do not meet the definition in the regulation (DOE 1994e). Floodplains are defined in 10 CFR 1022 as "the lowlands adjoining inland and coastal waters and relatively flat areas and flood prone areas of offshore islands including, at a minimum, that area inundated by a one percent or greater chance of flood in any given year." The floodplains at Rocky Flats do not adjoin inland bodies of water, nor are they relatively flat, flood prone areas. Although the streams that flow through the site have a mappable 100-year floodplain, these are not floodplains as defined in 10 CFR 1022, and therefore, floodplain requirements of 10 CFR 1022 do not apply.

Riparian areas along No Name Gulch and the areas adjacent to the East Landfill Pond have been identified as potential habitat for Preble's meadow jumping mouse, which is protected under the Colorado Nongame, Endangered, or Threatened Species Conservation Act. This act is a potential ARAR for OU 7. The Preble's meadow jumping mouse habitat is under investigation by the U.S. Fish and Wildlife Service. Given the current protection of the Preble's meadow jumping mouse under state law, DOE's commitment to protect natural resources under the Natural Resource Trustee Memorandum of Understanding, and the potential for listing Preble's meadow jumping mouse under the Endangered Species Act, habitat mitigation will be performed as needed.

Compliance with federal and state laws designed to preserve areas with historical, natural, cultural, or archaeological value requires the identification of cultural resources and prehistoric or historic artifacts located at OU 7. An archaeological and historical study of the Rocky Flats area was conducted in 1989 (Burney et al 1989). Cultural resource site density appears to be fairly low. The study found some evidence of short-term prehistoric use such as camping, hunting, and scattered historic settlement, however, the rocky terrain and thin soils prevented more intense, long-term use of the area. The historic preservation officer for the state of Colorado reviewed these findings and concluded that "there will be no effect on significant cultural resources by undertakings proposed" at Rocky Flats (CHS 1992).

3.4.3 Potential Action-Specific ARARs

Action-specific ARARs are management, performance, or treatment standards that are triggered by the particular activities that are selected to accomplish a remedy. Action-specific requirements do not, in themselves, determine the remedial alternative, rather, they indicate how a selected alternative must be achieved. Table 3-20 lists the potential federal and state action-specific ARARs that have been identified for OU 7. Table 3-21 lists standards and other guidance that have been identified as TBC. Action-specific ARARs most pertinent to OU 7 are RCRA and CHWA closure requirements, air-emission requirements, delisting requirements, discharge requirements under the National Pollutant Discharge Elimination System (NPDES), and post-closure groundwater-monitoring requirements.

3.4.3.1 Closure Requirements

The Present Landfill is being closed under interim status regulations in accordance with the IAG (DOE 1991a). CHWA and RCRA Subtitle C closure requirements are applicable because hazardous wastes were disposed in the Present Landfill after November 19, 1980, which is the effective date of RCRA (EPA 1993a). Two types of closure are allowed under RCRA Subtitle C: clean closure and landfill closure. The Present Landfill at OU 7 will be closed under landfill closure standards, which require post-closure care and maintenance of the unit for at least 30 years after closure (EPA 1989c). Closure ARARs require that the landfill must be capped with a final cover designed and constructed to provide long-term minimization of migration of liquids, function with minimum maintenance, promote drainage and minimize erosion, accommodate settling and subsidence, and have a permeability less than or equal to the natural subsoils present (6 CCR 1007-3, Section 265.310[a]). Post-closure care includes maintenance of the final cover and maintenance of a groundwater monitoring system (6 CCR 1007-3, Sections 265.117 and 265.228[b]).

3 4 3 2 Air-Emission Requirements

[revise with new TerraMatrix text]

Requirements for air pollution control and permitting for landfills are contingent on the type of landfill operation. At the federal level, landfills considered municipal solid waste landfills have been the subject of a rulemaking process that resulted in a proposed rule (56 FR 24468, May 30, 1991), a revision to the proposed rule (58 FR 33790, June 21, 1993), and significant internal and external review and comment. No final rule has been published at this time. Hazardous waste landfills permitted under RCRA are not covered under the proposed rules but are subject to specific requirements at the time of closure in terms of cap design and other monitoring. However, there are no specific provisions in the RCRA treatment, storage, and disposal facility regulations for air pollution controls.

Air pollution control permits in Colorado are issued by the Air Pollution Control Division of CDPHE. Requirements are outlined in Colorado Air Quality Control Commission (CAQCC) Regulation No. 3, Regulation Requiring an Air Pollution Emission Notice, Emission Permit Fees. Facilities subject to these requirements must file an Air Pollution Emission Notice (APEN) for each source or group of sources of uncontrolled emissions. Because the landfill closure falls under CERCLA, onsite actions must comply only with the substantive requirements, not the administrative requirements. Applicability can be triggered in any of three ways:

- First, for each potential emission point, a determination is made whether allowable emissions of criteria pollutants (CO, NO_x, SO₂, particulates [PM-10], total suspended particulates [TSP], ozone [O₃], VOCs, lead, fluorides, H₂SO₄ mist, H₂S, total reduced sulfur, reduced sulfur compounds, and municipal waste combustion products) are exceeded. Determinations are based on either actual measured data or on estimates developed by approved methods.
- Secondly, the Clean Air Act Amendments of 1990 added a program to control emissions of designated hazardous air pollutants (HAPs). Any source emitting more than 25 tons per year (tons/year) of total HAPs, or 10 tons/year of any individual HAP is required to apply for and obtain an operating permit from the permitting authority under the federal program. Colorado has developed its own system for evaluating the potential emissions of a designated set of HAPs based on the location of the emission point, its distance from the property line, the height of the release point, and the reporting bin, or category, of the pollutant being evaluated. This program is operated in lieu of the federal program and is considerably more stringent.
- Finally, specific categories of sources are required to file for permits based on standards developed for their operations. No specific requirements for municipal

solid-waste landfills currently exist in Colorado regulations and there are no plans to include specific requirements for those sources until federal regulations are finalized

Thresholds for triggering permit requirements are based on if the source is located in an attainment or non-attainment area, as defined in the regulations. Rocky Flats is located in a non-attainment area. The threshold limit for uncontrolled emissions of criteria pollutants is 1 ton/year. If it can be demonstrated that emissions of criteria pollutants from the entire facility are less than 1 ton/year, then no APEN is required.

Two determinations were made to evaluate the current or potential future applicability of air pollution permit requirements and gas controls for closure of the Present Landfill. First, a calculation of total nonmethane organic compounds (NMOCs) predicted to be generated by the landfill was made to determine if proposed federal air pollution control requirements for municipal landfills would apply. Second, calculations of emission rates of HAPs that trigger permitting requirements under CAQCC Regulation No. 3 were made.

The criteria pollutants most likely to trigger permitting requirements at OU 7 are VOCs. VOCs are any carbon compounds that participate in atmospheric photochemical reactivity. NMOCs measured at the site are made up largely of VOCs as defined in the regulations and, when added to the methane emissions, can serve as a surrogate for VOC emission estimates. Methods for estimating NMOC emissions from the landfill are described in the proposed federal regulations for municipal solid-waste landfills.

In May 1991, EPA proposed standards of performance for new municipal landfills and emission guidelines for existing municipal landfills. The rules included a threshold for applicability based on estimated or measured emissions of NMOCs of 150 Megagrams/year (Mg/yr), or approximately 167 tons/year. Formulas for estimating NMOC emissions were included in the regulation and best demonstrated technology (BDT) for control of those emissions was described. BDT is not provided as a specific technology but, instead, in terms of reduction of NMOCs by 98 weight-percent. This standard would apply to both new and existing sources. EPA identified several control systems believed to meet the 98 percent reduction criterion, including active collection and flare systems.

Formulas for estimating NMOC emissions were presented in the proposed federal regulation. At the initial level, estimates of NMOC emissions can be made based solely on the annual waste acceptance rates at the facility, without any sampling or monitoring data from the site. If that preliminary calculation shows the facility to be over the threshold of 150 Mg/yr, then additional calculations can be made following

site-specific sampling. If the year-to-year acceptance rate is uncertain, the alternative formula should be used

$$M_{\text{NMO}} = 2 L_o R (1 - e^{-kt}) (C_{\text{NMOC}}) (3.595 \times 10^9)$$

where M_{NMOC} = mass emission rate of NMOC (Mg/yr)

L_o = refuse methane generation potential (m^3/Mg refuse)

R = average annual acceptance rate (Mg/yr)

k = methane generation rate constant (1/yr)

t = age of landfill (yrs)

C_{NMOC} = concentration of NMOC (ppmv as hexane)

3.595×10^9 = conversion factor

In the absence of site-specific data, the values to be used in the equation are as follows

$$k = 0.02/\text{yr}$$

$$L_o = 230 \text{ m}^3/\text{Mg}$$

$$C_{\text{NMOC}} = 8,000 \text{ ppmv as hexane}$$

Using these factors, an estimate of NMOC emissions can be made. By using the measured methane to NMOC ratios from the Phase I RFI/RI (DOE 1994a), a total VOC estimate can be calculated and compared to the trigger values for VOC criteria pollutant emissions.

HAP emissions may also trigger permitting requirements. The methodology for determining applicability of permitting based on HAPs involves determining which of the three scenarios applies to the emission points, identifying the type of HAP by reporting bin, and comparing estimated emission levels to the threshold, or de minimis, levels defined in the regulations. Because most of the emission points from the capped landfill are likely to be 10 meters above ground level or less, limits from the first scenario are assumed to apply. The chemicals detected during soil-gas sampling (DOE 1994a) that are included on the HAP lists in Regulation No. 3 are shown in Table 3-22 along with their reporting bin and the de minimis threshold levels of annual emissions. Estimates of releases of these compounds from the landfill should be compared to these de minimis levels to determine if they trigger APEN requirements.

Concentrations of NMOCs are presented in Section 2.5.2. Trigger levels for the proposed emission standards for municipal solid waste landfills (56 FR 24468) set trigger levels for coverage at total NMOC emissions of 150 Mg/yr. Formulas for calculating total NMOC emissions are based on annual waste quantities placed in the landfill. Data from the OU 7 Final Work Plan (DOE 1994a) provide some measured

and some anecdotal data on waste quantities placed in the landfill over its life. Two different calculations were made, one based on estimated annual volumes and one based on the total volume placed over the life of the facility. Table 3-23 presents the results of those two estimates.

If estimates of yearly volumes of waste are used, the total annual predicted NMOC emissions are less than 1 Mg/yr, well below the threshold level of 150 Mg/yr. Alternatively, when the total waste volume anticipated in the landfill is used, the predicted NMOC emissions are approximately 54 Mg/yr. Finally, if the total volume of waste and fill (540,000 cy) is used in the equation, NMOC emissions are still only 107 Mg/yr. This last estimate overstates the potential NMOC emissions by including fill materials, presumably mostly inorganic soils, in the total waste volume generating NMOCs. This is the most conservative estimate that can be made and does not exceed the proposed 150 Mg/yr emission level.

These estimates can be compared to the measured NMOC concentrations from the Phase I RFI/RI methane survey (see Table 2-2). These concentrations varied widely from one part of the landfill to another, with peak concentrations as high as 147,000 ppm (mg/L). Even at this highest recorded concentration, however, gas-emission rates would need to be approximately 2,800 liters/day to lead to NMOC levels exceeding the 150 Mg/yr trigger level. Most NMOC levels measured were well below that peak level.

Concentrations of HAPs are presented in Section 2.5.2. HAPs detected at the landfill fall under the provisions of Colorado Air Regulation No. 3. De minimis levels of emissions are listed in Table 3-22. An estimate of the gas-emission rates that would be necessary to exceed the de minimis levels in the regulations, and thereby trigger Colorado air-permitting requirements, are also included in Table 3-22.

Many of the highest sampled concentrations shown in Table 3-22 are significantly higher than other sampling points for the same parameter. To make a more realistic comparison, the average of the five highest sampling points were calculated for each parameter and the estimated gas emission rates that would be necessary to exceed de minimis levels in the regulations were again calculated. As shown in Table 3-22, most of the parameters sampled would require extremely high gas emission rates to trigger HAP permitting levels. The high levels of methylene chloride, 1,2-dichloroethene, hydrogen sulfide, and 1,1,1-trichloroethane could each trigger HAP permitting levels at gas-emission rates that are not excessively high.

Based on the data reviewed, substantive requirements for a permit under Colorado Air Regulation No. 3 will have to be met for two reasons. First, the emissions of total VOCs (methane and NMOCs) will easily exceed the 1 ton/yr threshold level for a

major source. Second, at least some of the HAPs are present at concentrations that will likely lead to exceedances of the de minimis levels defined in the regulation, thus triggering permit requirements. Required controls and/or treatment of gas from the landfill will be up to Colorado regulatory authorities and will be negotiated as part of the permit review process.

3.4.3.3 *Delisting Requirements*

DOE proposes to delist landfill leachate, which is considered F039 RCRA-listed waste contained in groundwater under the NCP (EPA 1990a). The basis for delisting is that the leachate is not hazardous, does not exhibit hazardous-waste characteristics, and does not pose a threat to human health or the environment (see Section 3.3.4). In addition, the proposed remedy (landfill cap) will cover the seep area, prevent exposure to leachate, reduce contaminant leaching to groundwater, and ultimately reduce leachate generation and migration (see Section 2.3.5). A slurry wall will be constructed as a maintenance action to reduce groundwater inflow, leachate generation, and outflow at the seep. In addition, leachate will be collected and treated at the seep as an accelerated action for OU 7 before closure. As the landfill dewateres, leachate generation will be reduced and a decrease in contaminant concentrations in the leachate is expected. As outlined in the NCP (55 FR 8756, March 8, 1990), only the substantive requirements of delisting must be met for onsite CERCLA responses.

The substantive requirements of 40 CFR 260.20 and 260.22 are documented here and include a general discussion of why delisting is warranted, concentrations of each constituent remaining, comparison of actual concentrations to the maximum allowed concentrations (MACs) for specific constituents, results of fate and transport modeling to show calculated concentrations at a receptor well, and a contingency plan to address leachate that does not achieve delistable levels. These requirements are outlined in A Guide to Delisting of RCRA Wastes for Superfund Remedial Responses (EPA 1990b) and clarified in Petitions to Delist Hazardous Wastes - A Guidance Manual (EPA 1993b). EPA guidance requires upgradient and downgradient groundwater-monitoring data for delisting decisions (EPA 1993b). Upgradient data are summarized in the OU 7 Final Work Plan (DOE 1994a). Downgradient data are presented in this report. Statistical comparisons of upgradient data to downgradient data are presented in the Annual RCRA Groundwater Monitoring Report (EG&G 1994a).

Concentrations of contaminants in the leachate are presented in Tables 2-4, 3-1, and 3-16. Concentrations of contaminants in groundwater downgradient of the leachate seep are presented in Tables 2-10, 2-11, 3-11, 3-13, and 3-18. The text corresponding to these tables discusses the nature and extent of contamination (Sections 2.5.3 and 2.5.8), risk evaluations (Sections 3.3.4 and 3.3.8), and compliance with potential chemical-specific ARARs (Section 3.4.1). Table 3-24 provides a comparison of maximum

detected concentrations in leachate from the seep to MACs from the delisting guidance (EPA 1990b). The maximum detected concentration of only one analyte exceeds the MAC. The maximum detection of 1,1-dichloroethane in leachate is 10 ug/L, the MAC is 2 524 ug/L. However, the detection limit (5 ug/L) is also greater than the MAC. The potential ARAR for 1,1-dichloroethane is 1 ug/L.

Three-dimensional contaminant-transport modeling was performed using an analytical solution developed by Domenico and Robbins (1985) and coded into the TPLUME model (Golder and Associates 1989). This model was selected because leachate is transported downgradient by groundwater. The input parameters and Surfer plots of outputs are presented in Appendix E. Model simulations were performed for 1,1-dichloroethane in surficial materials. Well 53194 was used as the receptor well. The contaminant modeling showed that the MAC for 1,1-dichloroethane would not be exceeded at downgradient well 53194 at time equals 30 years (CHECK WITH DCR). As the landfill cap and slurry wall reduce leachate generation and migration, the water quality in the downgradient monitoring wells should improve over time. As mentioned before, the modeling results are overly conservative for several reasons:

- Constant source versus declining source assumption. The TPLUME model assumes a constant source of contamination over the entire period of the simulation. Actual conditions at OU 7 indicate a declining source(s). If the landfill mass is the source of contaminants, the proposed cap and slurry wall will reduce groundwater flow through the landfill and contaminant transport out of the landfill.
- Effect of the landfill pond dam as a barrier to contaminant migration. The TPLUME model does not take into account the effect of the dam as a barrier to contaminant migration. As described in Sections 2.3 and 2.5 and Appendix C, the dam has proven to be a significant barrier to groundwater flow and contaminant migration in surficial materials.

Under the presumptive remedy, it is proposed that the leachate be delisted (i.e., shown to be nonhazardous) and thus no longer be subject to CHWA and RCRA Subtitle C hazardous waste regulations. Instead, the leachate will be managed in accordance with CHWA and RCRA Subtitle D requirements, which are ARARs for leachate. If leachate or groundwater sampling during the closure or post-closure period shows that necessary levels (MACs) are not being attained for delisting, the leachate will be managed as Subtitle C hazardous waste and ARARs under Subtitle C will be met.

3.4.3.4 Discharge Requirements

Criteria and standards for NPDES (40 CFR Part 125) under the Clean Water Act and Colorado Water Quality Control Act are applicable under the IAG (DOE 1991a). Because OU 7 is an onsite CERCLA action, a NPDES permit is not required for

discharges from the East Landfill Pond to No Name Gulch. However, DOE will have to comply with the substantive provisions of these acts. In the short term, effluent limitations will be achieved through the accelerated action or leachate treatment system. In the long term, effluent limitations will be achieved with the final remedy or landfill cap. After closure, excess water in the East Landfill Pond will be discharged to No Name Gulch. Discharge requirements will be negotiated with CDPHE and EPA.

3.4.3.5 *Groundwater-Monitoring and Point-of-Compliance Requirements*

Post-closure groundwater-monitoring requirements are relevant and appropriate to interim status facilities such as the Present Landfill, and require implementation of a groundwater-monitoring program capable of determining the impact of the landfill on groundwater quality in the UHSU (6 CCR 1007-3, Section 265.90[a]). The requirement does not address the point of compliance for remediation activities. Because interim-status units and regulated units are addressed in a similar manner, the point-of-compliance provision that applies to regulated units is relevant and appropriate to the remediation of interim-status units (6 CCR 1007-3, Section 264.92).

The point-of-compliance is defined as the vertical surface that extends down into the UHSU at the downgradient limit of the waste-management area. Remediation levels should generally be attained "at and beyond the edge of the waste-management area when waste is left in place" (55 FR 8753). Although the downgradient limit of the waste-management area is currently at the toe of the landfill face, the cap will extend out towards the middle of the East Landfill Pond to achieve the maximum slope required for closure. As a result, the downgradient limit of the waste management area will shift to the east. Rather than installing monitoring wells in the middle of the pond, monitoring wells located downgradient of the dam will be proposed as compliance wells. Wells immediately downgradient of the dam are currently used as compliance wells for the annual RCRA groundwater-monitoring report, but these wells rarely yield enough groundwater for sampling. Wells farther downgradient are proposed as compliance wells.

Well 53194, which is located east of the dam and routinely yields enough groundwater for sampling, is proposed as the compliance well. The point of compliance is the hydrologically downgradient limit of the area in which contamination exists. The compliance well ensures that hazardous constituents detected in groundwater do not exceed concentration limits in the uppermost aquifer (or UHSU) underlying the waste management area beyond the point of compliance (6 CCR 1007-3, Sections 264.93 and 264.94). The regulations also provide that the owners or operators conduct a corrective-action program to remove or treat any hazardous constituents that exceed ARARs between the compliance point and the downgradient property boundary (6 CCR 1007-3, Section 264.95). Wells 4287 and 52894 are proposed as monitoring

wells for the detection-monitoring program at OU 7 to detect releases before the groundwater reaches the point of compliance

There is no potential for exposure to contaminated groundwater at OU 7. Future land use for the buffer zone, which includes the area downgradient of the landfill, is open space. Groundwater will not be used as a source of drinking water. In addition, No Name Gulch is a losing stream, which means that vertical gradients are downward and surface water recharges the groundwater in the UHSU. Groundwater is not discharged to surface water in No Name Gulch. The NCP states that attaining ARARs at the proposed point of compliance will ensure protection of human health and the environment at all points of potential exposure (55 FR 8753). DOE proposes a point of compliance for OU 7 downgradient of the dam, which is protective of human health and the environment. Potential chemical-specific ARARs can be met at this point.

3.5 Final Remedial Action Objectives or Response Actions

Final RAOs were developed based on the preliminary RAOs (Section 3.1), the conceptual site model for defining risks, exposure pathways, site risks, potential ARARs, and the presumptive remedy. A quantitative risk assessment is not necessary to evaluate whether the containment remedy addresses all pathways and contaminants of concern associated with the source. Rather, all potential exposure pathways identified using the conceptual site model were compared to the pathways addressed by the containment presumptive remedy (EPA 1993a). Exposure pathways addressed by the presumptive remedy include direct contact with the source and exposure to leachate and landfill gas.

For media not addressed by the presumptive remedy, EPA guidance (EPA 1993a) states that an active response is not required if contaminant concentrations exceed chemical-specific standards but the site risk is within the acceptable risk range ($1E-04$ to $1E-06$). Risks were evaluated and an ARARs comparison was performed, where appropriate, for these media. A reasonably anticipated future land use, the open-space scenario, was used for evaluating risks from exposure to leachate, surface water, and surface soils. Unlikely future land uses, residential recreational and onsite office-worker scenarios, were used for evaluating risks from exposure to pond sediment and groundwater downgradient of the landfill, respectively, for conservative bounding scenarios. Ultimately, it is necessary to demonstrate that the final remedy addresses all pathways and contaminants of concern.

3.5.1 Elimination of Preliminary RAOs

Preliminary RAOs that were eliminated from the final response action because there is no risk to the potential receptor, analytes do not exceed ARARs, or the exposure pathway is incomplete include the following:

- collect and treat leachate at the source (as needed)
- remediate surface water in the East Landfill Pond (as needed)
- remediate sediments in the East Landfill Pond (as needed)
- remediate surface soils in spray evaporation areas (as needed)
- control groundwater at the source to contain the plume
- remediate groundwater downgradient of the source (as needed)

The rationale for eliminating each of these RAOs is presented below

Potential exposure to landfill leachate will be addressed by the presumptive remedy for source containment (Figure 3-6). The proposed landfill cap will cover the seep area and prevent exposure to leachate, reduce contaminant leaching to groundwater, and ultimately reduce leachate generation and migration. A slurry wall will be constructed as a maintenance action to address the failure of the existing groundwater intercept system and north slurry wall and reduce groundwater inflow, leachate generation, and outflow at the seep. In addition, leachate will be collected and treated at the seep as an accelerated action for OU 7 before closure. Leachate collection and removal activities are not required for interim-status units (6 CCR 1007-3 Part 265.310).

Based on the results of the PRG screen and ecological risk assessment, there is no associated risk to human health from landfill leachate. The cumulative risk for avian and terrestrial wildlife, expressed as the hazard index, was greater than 1.0 for mallards, raccoons, and coyotes. Because it was assumed that these species spend all of their time at the East Landfill Pond, risk was probably overestimated. Based on the results of an ARARs comparison, nine analytes exceed ARARs in landfill leachate; they are cobalt, manganese, zinc, 2-methylnaphthalene, naphthalene, 1,1-dichloroethane, 1,2-dichloroethene, chloroethane, and vinyl chloride. Only one analyte (1,1-dichloroethane) is above MACs for delisting, and the detection limit for 1,1-dichloroethane is greater than the MAC.

DOE proposes to continue monitoring the leachate using risk-based trigger levels to determine if future collection and treatment is required until the slurry wall is in place and the landfill cover is constructed. After the containment presumptive remedy is in place, the seep discharge point will be covered, approximately 94 percent of the source water will be eliminated (see Section 2.3), and the pathway for exposure of human and ecological receptors to leachate will be incomplete.

Based on the results of the PRG screen and ecological risk assessment, there is no associated risk to human health or terrestrial or aquatic organisms from surface water in the pond. None of the surface water PCOCs exceeded state water quality standards or risk-based benchmarks. The cumulative risk, expressed as the hazard index, was greater than 1.0 only for mallards. Because it was assumed that mallards spend all of

their time at the East Landfill Pond, risk to mallards was probably overestimated. The pond is in compliance with potential ARARs for surface water.

DOE proposes to leave the portion of the pond and wetlands not covered by the cap in place. The East Landfill Pond includes approximately 3 percent of the open-water habitat and 6 percent of the available shoreline habitat at Rocky Flats; the adjacent wetland represents approximately 1.6 percent of the total wetland area at Rocky Flats (COE 1994). The pond area has been identified as potential habitat for one federal candidate species, Preble's meadow jumping mouse (DOE 1995b), but their occurrence there has not been confirmed. It is possible that other state or federally protected species may use the pond area occasionally (DOE 1995b). The dam acts as a barrier to groundwater migration and is effective in preventing contaminants in groundwater from migrating down No Name Gulch.

Based on the results of the PRG screen and the ecological risk assessment, no response action is required for sediments in the East Landfill Pond because the sediments pose no risk to human health and minimal risk to aquatic life and wildlife. DOE proposes to leave the pond sediments in place.

Because carcinogenic risks fall below or within the EPA acceptable risk range of $1\text{E-}04$ to $1\text{E-}06$ and noncarcinogenic risks are below the hazard index of 1, surface soils do not require a response action (EPA 1993a). DOE proposes to leave the surface soils in the vicinity of spray evaporation areas in place.

Source-area groundwater control to contain the plume will be addressed several ways. As discussed in Section 2.3.5, the presumptive remedy (landfill cap and slurry wall) will reduce inflow to the landfill by approximately 94 percent, which will reduce the flow rate of the leachate seep. The proposed landfill cap will cover the seep area, which will reduce contaminant leaching to groundwater. Groundwater modeling has shown that migration is likely slowed considerably or possibly even stopped by the dam. Discharge from groundwater to surface water is not expected downgradient of the dam. Discharge does occur to the pond. The intermittent stream in No Name Gulch is a losing stream that discharges to groundwater. Groundwater in the UHSU may also seep down into the confining layers of the unweathered bedrock; however, hydraulic conductivity values for the confining layer are low and downward seepage is minimal.

There are no potential exposure pathways associated with groundwater downgradient of the landfill. However, for the purpose of evaluating potential future risks, ingestion of groundwater from downgradient wells by an office worker was used as an exposure scenario. The carcinogenic risk from ingestion of UHSU groundwater in the vicinity of the pond upgradient of the dam is within the acceptable risk range of $1\text{E-}04$ to $1\text{E-}06$ ($1\text{E-}05$), however, the noncarcinogenic risk is above the acceptable risk or hazard index.

of 1 (HI = 3) The primary contributor to noncarcinogenic risk is selenium (HI = 1.5) The risks from ingestion of UHSU groundwater downgradient of the dam are within the acceptable risk range (carcinogenic risk less than 1E-06, noncarcinogenic risk, HI = 0.2) Therefore, there is minimal risk to future onsite office workers from ingestion of UHSU groundwater and the potential exposure pathway associated with UHSU groundwater downgradient of the landfill is incomplete (no one will be ingesting groundwater from wells)

Four analytes actually exceed ARARs in UHSU groundwater downgradient of the landfill, they are selenium, chloride, nitrate/nitrite, and sulfate Selenium exceeds ARARs only in groundwater in the vicinity of the pond Contaminant-transport modeling indicates that concentrations of selenium in groundwater will exceed ARARs at the point of compliance in 30 years (Appendix E), however, the modeling neglected the effects of the dam, which would likely impede the migration of contaminants, and also assumes that concentrations in weathered bedrock exist in surficial materials (see Section 2.5.7) In addition, the pond area will be covered by the landfill cap, reducing the amount of recharge to groundwater in this area Chloride, nitrate/nitrite, and sulfate exceed ARARs in groundwater in the vicinity of the pond and downgradient of the dam Contaminant-transport modeling indicates that concentrations of sulfate in groundwater will exceed ARARs at the point of compliance in 30 years because the sulfate source appears to be downgradient of the dam (Appendix E) The groundwater modeling is excessively conservative because it assumes a constant source, concentrations in weathered bedrock were used as source terms for surficial-materials modeling as a result of data gaps, and the model assumes homogeneous, isotropic conditions and does not take into account the effect of the dam (see Section 3.4.1.3)

Wells downgradient of the dam that meet potential ARARs for UHSU groundwater include 4287, 52894, and 53194 These wells are proposed as downgradient wells for the post-closure groundwater-monitoring system (6 CCR 1007-3, Section 265.90[a]) Samples collected from these wells are representative of groundwater quality downgradient of the landfill and the wells are capable of detecting groundwater contamination Any one of these wells would be suitable as the point of compliance for OU 7 DOE proposes to continue monitoring the groundwater during the post-closure care period

3.5.2 Development of Final RAOs

Final RAOs that will be used for the identification and screening of technologies and the development of alternatives include the following

- prevent direct contact with landfill contents
- minimize infiltration and resulting contaminant leaching to groundwater

- control surface-water runoff and erosion
- control landfill gas (treat as needed)
- remediate wetland areas (as needed)

Direct contact with soil or waste material in the Present Landfill, IHSS 203, and the asbestos disposal areas will be prevented by a RCRA-equivalent landfill cover. Because the continued effectiveness of the containment remedy depends on the integrity of the containment system, institutional controls will be necessary to prevent access to the site. A deed notation under the Colorado Hazardous Waste Act is needed to prevent future development of the landfill area.

The containment remedy will also minimize infiltration and resulting contaminant leaching and control surface-water runoff and erosion. Contaminant leaching will be decreased by reducing infiltration of precipitation through the landfill cover and controlling surface-water flow by diverting it around the landfill. Routine maintenance actions, such as replacing the slurry wall on the north side of the landfill, will reduce contaminant leaching by controlling groundwater inflow into the landfill area. Grading of the landfill surface will control surface-water flow. Revegetation will stabilize the soil.

Exposure to landfill gas will be controlled by a passive gas-venting system. Discharge points with standard burners for treatment of the gas will be installed as needed. The remedial action will comply with substantive aspects of air emissions requirements.

Wetland areas will be remediated as needed. The loss of wetland areas that fall under the proposed footprint of the landfill cover and injury to remaining wetland areas will be mitigated. Acreage adjacent to the Standley Lake Protection Project will be used to mitigate onsite wetlands impacted by construction of the final remedial action for landfill closure.

Table 3-1
Preliminary Remediation Goal (PRG) Screen
for Leachate from the Seep
at

PCOC	Maximum Detected Concentration	Location of Maximum	Open Space Surface Water PRG1	Units	Maximum > PRG?2
Metals					
Antimony	60.4	SW097	13,600	µG/L	no
Barium	1,550	SW097	2,380,000	µG/L	no
Iron	155,000	SW097	-	µG/L	no
Lithium	107	SW097	681,000	µG/L	no
Manganese	2,490	SW097	170,000	µG/L	no
Strontium	1,370	SW097	20,400,000	µG/L	no
Zinc	16,000	SW097	10,200,000	µG/L	no
Radionuclides					
Strontium 89,903	4.06	SW097	795	PCI/L	no
Tritium	1,500	SW097	823,000	PCI/L	no
Indicator Water Quality Parameters					
Nitrite	63	SW097	3,410,000	µG/L	no
Semivolatile Organic Compounds					
2,4-Dimethylphenol	3	SW097	681,000	µG/L	no
2-Methylnaphthalene	23	SW097	-	µG/L	no
4-Methylphenol	4	SW097	-	µG/L	no
Acenaphthene	3	SW097	2,040,000	µG/L	no
Bis(2-Ethylhexyl)Phthalate	2	SW097	5,680	µG/L	no
Dibenzofuran	2	SW097	-	µG/L	no
Diethyl Phthalate	3	SW097	27,300,000	µG/L	no
Fluorene	3	SW097	1,360,000	µG/L	no
Naphthalene	22	SW097	1,360,000	µG/L	no
Phenanthrene	5	SW097	-	µG/L	no
Volatile Organic Compounds					
1,1-Dichloroethane	10	SW097	3,410,000	µG/L	no
1,2-Dichloroethane	14	SW097	307,000	µG/L	no
2-Butanone	76	SW097	20,400,000	µG/L	no
2-Hexanone	10	SW097	-	µG/L	no
4-Methyl-2-Pentanone	87	SW097	2,730,000	µG/L	no
Acetone	220	SW097	3,410,000	µG/L	no
Benzene	2	SW097	2,740	µG/L	no
Chloroethane	57	SW097	-	µG/L	no
Chloromethane	7	SW097	6,110	µG/L	no
Ethylbenzene	18	SW097	3,410,000	µG/L	no

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PCOC	Maximum Detected Concentration	Location of Maximum	Open Space Surface Water PRG1	Units	Maximum > PRG?2
Toluene	88	SW097	6 810,000	µG/L	no
Total Xylenes	25	SW097	68 100 000	µG/L	no
Tnchloroethene	4	SW097	7,230	µG/L	no
Vinyl Chloride	11	SW097	41 8	µG/L	no
o Xylene4	8	SW097	68 100 000	µG/L	no

~~No PRG Is Available~~

- 1 ~~Prs Were Provided By EG&G (Draft Programmatic Prs For Rocky Flats Plant - Open Space 3/29/95)~~
- 2 ~~If The Maximum Detected Concentration Is Greater Than The PRG, The Analyte Is Evaluated In A Risk Assessment Prs Are Developed For Those Analytes With Toxicity Criteria Only Analytes With Prs Are Evaluated In A Risk Assessment If No Maximum Detected Concentrations Exceed The PRG, A Risk Assessment Is Not Performed~~
- 3 ~~The PRG Is For Strontium-90 And Daughter Products Because It Is More Conservative Than The PRG For Strontium-89~~
- 4 ~~The PRG Is For Total Xylenes~~ SMT

Table 3-2
Preliminary Remediation Goal (PRG) Screen
for Surface Water from the East Landfill Pond

PCOC	Maximum Detected Concentration	Location of Maximum	Open Space Surface Water PRG ¹	Units	Maximum > PRG? ²
Metals					
Arsenic	2.2	SW098	45.4	µG/L	no
Lithium	109	SW098	681,000	µG/L	no
Manganese	430	SW098	170,000	µG/L	no
Molybdenum	13.1	SW098	170,000	µG/L	no
Nickel	22	SW098	681,000	µG/L	no
Strontium	598	SW098	20,400,000	µG/L	no
Thallium	7.4	SW098	---	µG/L	no
Tin	44.3	SW098	20,400,000	µG/L	no
Radionuclides					
Americium-241	0.031	SW098	136	PCI/L	no
Strontium-89,90 ³	1.924	SW098	795	PCI/L	no
Tritium	257.8	SW098	823,000	PCI/L	no
Uranium-235 ⁴	0.3	SW098	946	PCI/L	no
Uranium-238 ⁵	1.964	SW098	717	PCI/L	no
Semivolatile Organic Compounds					
Bis(2-Ethylhexyl)Phthalate	1	SW098	5,680	µG/L	no
Di-N-Butyl Phthalate	1	SW098	3,410,000	µG/L	no

-- No PRG is available

- 1 Prgs Were Provided By EG&G (Draft Programmatic Prgs For Rocky Flats Plant - Open Space 3/29/95)
- 2 If The Maximum Detected Concentration Is Greater Than The PRG, The Analyte Is Evaluated In A Risk Assessment Prgs Are Developed For Those Analytes With Toxicity Criteria Only Analytes With Prgs Are Evaluated In A Risk Assessment If No Maximum Detected Concentrations Exceed The PRG, A Risk Assessment Is Not Performed
- 3 The PRG Is For Strontium-90 And Daughter Products Because It Is More Conservative Than The PRG For Strontium-89
- 4 The PRG Is For Uranium-235 And Daughter Products
- 5 The PRG Is For Uranium-238 And Daughter Products

Table 3-3

SELECTION OF SEDIMENT COCS FOR EAST LANDFILL POND RISK ANALYSIS
~~PRELIMINARY REMEDIATION GOAL SCREEN~~ *Sediment from the*

Analyte	Maximum Concentration	Detection Frequency	Normal Background UTL _{99/99} (1)	Sediment PPRG (2)	Analyte Considered a COC?	Rationale
Metals (in mg/kg)						
Aluminum	16 600	2/2	29 600	NA	No	<Background UTL _{99/99}
Arsenic	5	3/3	67	NA	No	<Background UTL _{99/99}
Barium	215	3/3	795	NA	No	<Background UTL _{99/99}
Beryllium	1 5	3/3	2 6	NA	No	<Background UTL _{99/99}
Cadmium	7,850	2/2	80,900	NA	No	<Background UTL_{99/99}
Chromium	17 5	3/3	29 5	NA	No	<Background UTL _{99/99}
Copper	18 6	3/3	175 4	NA	No	<Background UTL _{99/99}
Iron	15 400	2/2	143,900	NA	No	<Background UTL_{99/99}
Lead	33 7	3/3	261 1	NA	No	<Background UTL _{99/99}
Magnesium	3,250	2/2	6,470	NA	No	<Background UTL_{99/99}
Nickel	15 3	3/3	35 2	NA	No	<Background UTL _{99/99}
Potassium	2,640	2/2	3,227	NA	No	<Background UTL_{99/99}
Selenium	1 1	3/3	5 2	NA	No	<Background UTL _{99/99}
Sodium	447	2/2	2,127	NA	No	<Background UTL_{99/99}
Strontium	61 5	2/2	356	NA	No	<Background UTL _{99/99}
Vanadium	41	3/3	86 0	NA	No	<Background UTL _{99/99}
Zinc	187	3/3	148	>1E+06	No	<Sediment PPRG
Radionuclides (in pCi/g)						
Cesium-137	0 732	3/3	3 51	NA	No	<Background UTL _{99/99}
Volatile Organic Compounds (in mg/kg)						
Acetone	0 13	2/3	NA	>1E+06	No	<Sediment PPRG
2-Butanone	0 035	1/3	NA	>1E+06	No	<Sediment PPRG
Toluene	0 44	3/3	NA	>1E+06	No	<Sediment PPRG
Semivolatile Organic Compounds (in mg/kg)						
Acenaphthene	0 1	1/3	NA	>1E+06	No	<Sediment PPRG
Acenaphthylene	0 18	2/3	NA	NA	No	No toxicity factors
Anthracene	0 16	1/3	NA	>1E+06	No	<Sediment PPRG
Benzo(a)anthracene	0 34	1/3	NA	2 33E+02	No	<Sediment PPRG
Benzo(a)pyrene	0 32	1/3	NA	2 33E+01	No	<Sediment PPRG
Benzo(b)fluoranthene	0 45	1/3	NA	2 33E+02	No	<Sediment PPRG
Benzo(ghi)perylene	0 2	1/3	NA	NA	No	No toxicity factors
Benzo(k)fluoranthene	0 13	1/3	NA	2 33E+03	No	<Sediment PPRG
Benzoic acid	0 87	3/3	NA	>1E+06	No	<Sediment PPRG
bis(2-Chloroisopropyl)ether	0 047	1/3	NA	2 43E+03	No	<Sediment PPRG
bis(2-Ethylhexyl)phthalate	0 08	1/3	NA	1 22E+04	No	<Sediment PPRG
Chrysene	0 31	1/3	NA	2 33E+04	No	<Sediment PPRG
Fluoranthene	0 83	2/3	NA	>1E+06	No	<Sediment PPRG
Fluorene	0 092	1/3	NA	>1E+06	No	<Sediment PPRG
Indeno(1,2 3-cd)pyrene	0 18	1/3	NA	2 33E+02	No	<Sediment PPRG
Phenanthrene	0 73	2/3	NA	NA	No	No toxicity factors
Pyrene	0 75	2/3	NA	>1E+06	No	<Sediment PPRG

COCs = Chemicals of concern

UTL_{99/99} = Upper tolerance limit of the 99th percentile at the 99% confidence level

PPRG = Programmatic preliminary remediation goal

- (1) Statistical background comparisons were not performed due to the small OU7 sample size (3). Rather the maximum concentration of each analyte was compared to the background UTL_{99/99} concentration for seep sediments. Background pond sediment samples were not collected. Background samples are assumed to be normally distributed since this is the most conservative assumption.
- (2) All organic constituents and inorganics exceeding their respective background UTL_{99/99} are compared to the sediment PPRG developed using a residential/recreational RME exposure scenario (see attached).
- NA = Not applicable

Table 3-4
Preliminary Remediation Goal (PRG) Screen
for Surface Soils in the vicinity of Spray Evaporation Areas

PCOC	Maximum Detected Concentration	Location of Maximum	Open Space Soil PRG1	Units	Maximum > PRG?2
Metals					
Antimony	9 1	SS719693	3,070	MG/KG	no
Arsenic	15 7	SS702293	10	MG/KG	YES
Barium	1,120	SS705193	535,000	MG/KG	no
Beryllium	1 5	SS120894	4 08	MG/KG	no
Cobalt	16 2	SS712093	461,000	MG/KG	no
Copper	640	SS121394	307,000	MG/KG	no
Lead	167	SS708893	---	MG/KG	no
Mercury	0 14	SS708693	2,310	MG/KG	no
Selenium	2 9	SS121594	38,400	MG/KG	no
Silver	3	SS709593	38,400	MG/KG	no
Strontium	80 6	SS720193	>1,000,000	MG/KG	no
Thallium	2 1	SS121594	---	MG/KG	no
Vanadium	86 2	SS705293	53,800	MG/KG	no
Zinc	113	SS120894	>1,000,000	MG/KG	no
Radionuclides					
Americium-241	1 076	SS703793	23 6	PCI/G	no
Plutonium-239/240	0 4692	SS704293	69 8	PCI/G	no
Radium-2263	1 787	SS711193	0 0247	PCI/G	YES
Indicator Water Quality Parameters					
Nitrate/Nitrite	45	SS710893	>1,000,000	MG/KG	no
Total Organic Carbon	54,000	SS701193	---	MG/KG	no

--- no PRG is available

- 1 PRGs were provided by EG&G (Draft Programmatic PRGs for Rocky Flats Plant - Open Space 3/29/95)
- 2 If the maximum detected concentration is greater than the PRG, the analyte is evaluated in the risk assessment (Tables 3-8, 3-9, and 3-10) PRGs are developed for those analytes with toxicity criteria. Only analytes with PRGs are evaluated in the risk assessment.
- 3 The PRG is for radium-226 and daughter products.

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Table 3-5
Site-Specific Exposure Factors for Incidental Ingestion of Surface Soil¹

Exposure Factor	Abbreviation	Reasonable Maximum Exposure (RME) Value		Units
		Child	Adult	
Ingestion Rate	IR	100	50	mg/visit
Matrix Effect in GI Tract (Absorption Factor)	ME	chemical specific ²	chemical specific ²	unitless
Exposure Frequency	EF	25	25	visits/year
Exposure Duration	ED	6	24	years
Body Weight	BW	15	70	kg
Averaging Time - Noncarcinogen	ATN	2,190	8,760	days
Averaging Time - Carcinogen	ATC	25,550	25,550	days

¹ Exposure parameters were provided by EG&G (Final Open-Space Exposure Parameters, 5/31/95)

² All absorption factors are 1, conservatively assuming 100% absorption

Table 3-6
Site-Specific Exposure Factors for Particulate Inhalation of Surface Soil¹

Exposure Factor	Abbreviation	Reasonable Maximum Exposure (RME) Value Adult	Units
Inhalation Rate	IR	1 4	m3/hour
Particulate Emission Factor	PEF	4 63E+10	m3/kg
Respirable Fraction (PM10)	RF	0 46	unitless
Respiratory Deposition Factor	DF	0 85	unitless
Exposure Time	ET	5 0	hours/visit
Exposure Frequency	EF	25	visits/year
Exposure Duration	ED	30	years
Body Weight	BW	70	kg
Averaging Time - Carcinogen	ATC	25,550	days

¹ Exposure parameters were provided by EG&G (Final Open-Space Exposure Parameters 5/31/95) and Risk Assessment Guidance for Superfund, Volume I Human Health Evaluation Manual, Part B (EPA 1991)

Table 3-7
Site-Specific Exposure Factors for External Irradiation from Surface Soil¹

Exposure Factor	Abbreviation	Reasonable Maximum Exposure (RME) Value Adult	Units
Gamma Exposure Time Factor	ET	0.2	unitless
Gamma Shielding Factor	SF	1.0	unitless
Exposure Frequency Ratio	EF	0.07	unitless
Exposure Duration	ED	30	years

¹ Exposure parameters were provided by EG&G (Final Open-Space Exposure Parameters 5/31/95)

Table 3-8
Potential Risks Associated with Incidental Ingestion of Surface Soils at OU 71
Open-Space Exposure Scenario

Child Exposure									
Carcinogens	UCL_{as}		Intake²				Oral Cancer Slope Factor³		Carcinogenic Risk
	5.5	mg/kg	0.039	mg/kg-day	0.00000022	mg/kg-day	1.75E+01	(mg/kg-day) ⁻¹	
Arsenic									4E-06
Radium-226	1.0	pCi/g	15,000	mg	16	pCi	2.95E-09	risk/pCi	5E-08
Total Carcinogenic Risk									
4E-06									
Noncarcinogens	UCL_{as}		Intake²				Chronic Reference Dose³		Hazard Quotient
	5.5	mg/kg	0.457	mg/kg-day	0.00000025	mg/kg-day	3E-03	mg/kg-day	
Arsenic									0.008
Hazard Index									
0.008									

Adult Exposure									
Carcinogens	UCL_{as}		Intake²				Oral Cancer Slope Factor³		Carcinogenic Risk
	5.5	mg/kg	0.017	mg/kg-day	0.000000092	mg/kg-day	1.75E+01	(mg/kg-day) ⁻¹	
Arsenic									2E-06
Radium-226	1.0	pCi/g	30,000	mg	31	pCi	2.95E-09	risk/pCi	9E-08
Total Carcinogenic Risk									
2E-06									
Noncarcinogens	UCL_{as}		Intake²				Oral Chronic Reference Dose³		Hazard Quotient
	5.5	mg/kg	0.049	mg/kg-day	0.00000027	mg/kg-day	3E-03	mg/kg-day	
Arsenic									0.0009
Hazard Index									
0.0009									

1 Risks were calculated for those chemicals with oral toxicity criteria. Slight rounding may occur.

2 Exposure factors used to calculate intake for incidental ingestion of surface soil in an open-space exposure scenario are presented in Table 3-5.

3 Oral toxicity values are from DOE (February 1995) and HEAST (November 1994).

(PCOCs identified from the PRG screen [Table 3-4])

Open Space Exposure Scenario

Table 3-9
Potential Risks Associated with Particulate Inhalation of Surface Soils at OU 71

Carcinogens	UCL ₉₅		Intake ²		Inhalation Cancer Slope Factor ³	Carcinogenic Risk
Arsenic	5.5	mg/kg	1.4E-12	mg/kg-day	1.51E+01 (mg/kg-day) ⁻¹	2E-11
Radium-226	1.04	pCi/g	4.6E-04	pCi	2.72E-09 risk/pCi	1E-12
Total Carcinogenic Risk						2E-11

- 1 Risks were calculated for those chemicals with inhalation toxicity criteria. Slight rounding may occur.
 - 2 Exposure factors used to calculate intake for particulate inhalation of surface soil in an open-space exposure scenario are presented in Table 3-6.
 - 3 Inhalation toxicity values are from DOE (February 1995) and HEAST (1994).
- (PCOCs identified from the PRG screen [Table 3-4])
 Open-Space Exposure Scenario

Table 3-10
Potential Risks Associated with External Irradiation from Surface Soils at OU 71

Carcinogens	UCL ₉₅		External Exposure ²		External Exposure Cancer Slope Factor ³	Carcinogenic Risk
Radium-226	1.04	pCi/g	0.44	pCi-yr/g	1.31E-08 risk/yr per pCi/g soil	6E-09
Total Risk						6E-09

- 1 Risks were calculated for those chemicals with external exposure toxicity criteria. Slight rounding may occur.
 - 2 Exposure factors used to calculate intake for external irradiation from surface soil in an open-space exposure scenario are presented in Table 3-7.
 - 3 External exposure values are from HEAST (November 1994).
- (PCOCs identified from the PRG screen [Table 3-4])
 Open-Space Exposure Scenario

Table 3-11
Preliminary Remediation Goal (PRG) Screen for Downgradient Groundwater

PCOC	Maximum Detected Concentration	Location of Maximum	Residential Groundwater PRG1	Units	Maximum > PRG?2
UHSU Groundwater in the Vicinity of the East Landfill Pond					
Metals					
Antimony	58	B206789	14.6	µG/L	yes
Lithium	225	B206789	730	µG/L	no
Selenium	815	B206789	182	µG/L	yes
Silver	10.9	B206789	182	µG/L	no
Strontium	1,560	B206789	21,900	µG/L	no
Radionuclides					
Uranium 2383	35.45	B206889	2.38	PCI/L	yes
<i>Indicates</i> Water quality parameters					
Bicarbonate as CaCO3	860,000	0786		µG/L	no
Chloride	460,000	B206889		µG/L	no
Nitrate/nitrite4	290,000	B206889	58,400	µG/L	yes
Orthophosphate	30	B206789	-	µG/L	no
Sulfate	1,600,000	B206889	-	UG/L	no
Total dissolved solids	3,700,000	B206889		µG/L	no
Semivolatile organic compounds					
Bis(2-ethylhexyl)phthalate	3	B206789	6.07	µG/L	no
Volatile organic compounds					
Carbon tetrachloride	7.11	B206889	0.26	µG/L	yes
Tetrachloroethene	0.769	B206889	1.43	µG/L	no
Trichloroethene	1.43	B206889	2.55	µG/L	no
UHSU groundwater downgradient of the dam					
Metals					
Lithium	138	B207089	730	µG/L	no
Strontium	1,870	B207089	21,900	µG/L	no
Radionuclides					
Strontium 89/905	0.49	4287	1.32	PCI/L	no
<i>Indicates</i> Water quality parameters					
Bicarbonate as CaCO3	670,000	B207089	-	µG/L	no
Carbonate as CaCO3	12,000	4087	-	µG/L	no
Chloride	530,000	B207089	-	µG/L	no
Fluoride	3,400	4087	2,190	µG/L	yes
Nitrate/Nitrite4	72,000	B206989	58,400	µG/L	yes
Orthophosphate	150	4287	-	µG/L	no

PCOC	Maximum Detected Concentration	Location of Maximum	Residential Groundwater PRG1	Units	Maximum > PRG?2
Sulfate	19 000 000	B207089		µG/L	no
Total dissolved solids	5 100 000	B206989	-	µG/L	no

-- no PRG is available

- 1 PRGs were provided by EG&G (Final Programmatic Risk-Based Preliminary Remediation Goals Revision 2 [DOE February 1995])
- 2 If the maximum detected concentration is greater than the PRG the analyte is evaluated in the risk assessment (Table 3-13) PRGs are developed for those analytes with toxicity criteria Only analytes with PRGs are evaluated in the risk assessment
- 3 The PRG is for uranium-238 and daughter products
- 4 The PRG is for nitrate because it is the dominant species present
- 5 The PRG is for strontium-90 and daughter products because it is more conservative than the PRG for strontium-89

Table 3-12
Rocky Flats Site-Specific Exposure Factors for Groundwater Ingestion¹

Exposure Factor	Abbreviation	Reasonable Maximum Exposure (RME) Value	Units
		Adult	
Ingestion Rate	IR	1 0	L/day
Fraction Ingested from Contaminated Source	FI	1 0	unitless
Exposure Frequency	EF	250	days/year
Exposure Duration	ED	25	years
Body Weight	BW	70	kg
Averaging Time - Noncarcinogen	ATN	9,125	days
Averaging Time - Carcinogen	ATC	25,550	days

¹ Exposure parameters were provided by EG&G (Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment 5/1/95)

Table 3-13
Potential Risks Associated with Groundwater Ingestion at OU 71

UHSU Groundwater Upgradient of the Dam

Carcinogens	UCL₉₅	Intake²		Oral Cancer Slope Factor³	Carcinogenic Risk
Carbon Tetrachloride	2.7	μg/L	0.0000094	1.3E-01 (mg/kg-day) ⁻¹	1E-06
Uranium-2384	35	pCi/L	221,563	4.27E-11 risk/pCi	9E-06
Total Carcinogenic Risk					1E-05

Noncarcinogens	UCL₉₅	Intake²		Oral Chronic Reference Dose³	Hazard Quotient
Antimony	32	μg/L	0.00031	4E-04 mg/kg-day	0.8
Carbon Tetrachloride	2.7	μg/L	0.000026	7E-04 mg/kg-day	0.04
Nitrate/Nitrite ⁵	69,339	μg/L	0.68	1.6E+00 mg/kg-day	0.4
Selenium	749	μg/L	0.0073	5E-03 mg/kg-day	1.5
Hazard Index					3

UHSU Groundwater Downgradient of the Dam

Noncarcinogens	UCL₉₅	Intake²		Oral Chronic Reference Dose³	Hazard Quotient
Fluoride	894	μg/L	0.0088	6E-02 mg/kg-day	0.1
Nitrate/Nitrite ⁵	12,849	μg/L	0.13	1.6E+00 mg/kg-day	0.08
Hazard Index					0.2

1 Risks were calculated for those chemicals with oral toxicity criteria. Slight rounding may occur.

2 Exposure factors used to calculate intake for groundwater ingestion in a future on-site office worker exposure scenario are presented in Table 3-12.

3 Oral toxicity values are from DOE (February 1995) and HEAST (November 1994).

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- 4 The maximum detected concentration was used to calculate risk because the UCL95 is greater than the maximum detected concentration
- 5 The oral chronic reference dose is for nitrate because it is the dominant species present
(PCOCs identified from the PRG screen [Table 3-11])
Future On-Site Office-Worker Exposure Scenario

Table 3-14
Potential Chemical-Specific ARARs for Surface Water

Analyte	ARAR/ TBC	Unit	Law/Regulation	Citation
Metals				
Aluminum	87	ug/L	Colorado Water Quality Standard, AQ	5 CCR 1002-8, 3 1 11
Antimony	300	ug/L	PQL	
Arsenic	50	ug/L	SDWA MCL	40 CFR 141
Barium	1 000	ug/L	RCRA MCL	40 CFR 264 94
Beryllium	4	ug/L	Segment 4 & 5 Standard	Standard is 1-day average
Cadmium	TVS		Segment 4 & 5 Standard	
Chromium	50	ug/L	RCRA MCL	40 CFR 264 94
Cobalt	50	ug/L	Colorado Water Quality Standard, AG	5 CCR 1002-8 3 1 11
Copper	TVS		Segment 4 & 5 Standard	
Lead	TVS		Segment 4 & 5 Standard	
Lithium	2500	ug/L	Colorado Water Quality Standard, AG	5 CCR 1002-8 3 1 11
Manganese	50	ug/L	Colorado Water Quality Standard	5 CCR 1002-8, 3 1 11
Mercury	10	ug/L	Segment 4 & 5 Standard	
Nickel	125	ug/L	Segment 4 & 5 Standard	
Selenium	17	ug/L	Colorado Water Quality Standard	5 CCR 1002-8, 3 1 11
Silver	50	ug/L	RCRA MCL	40 CFR 264 94
Tin	8,000	ug/L	PQL	
Vanadium	100	ug/L	Colorado Water Quality Standard, AG	5 CCR 1002-8, 3 1 11
Zinc	2,000	ug/L	Colorado Water Quality Standard, AG	5 CCR 1002-8 3 1 11
Radionuclides				
Americium 241	30	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Cesium 137	3000	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Plutonium 239, 240	30	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Plutonium 238	30	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Plutonium 239	30	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5

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Analyte	ARAF/ TBC	Unit	Law/Regulation	Citation
Radium 226	100	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Strontium 89 90	8	pCi/L	SDWA MCL	40 CFR 141
Strontium 90		pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Tritium	1,000	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Uranium 233 234	500	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Uranium 235	600	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Uranium 238	600	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Water Quality Parameters				
Cyanide	200	ug/L	SDWA MCL	40 CFR 141
Fluoride	2,000	ug/L	Colorado Water Quality Standard DW	5 CCR 1002-8 3 1 11
Nitrate/Nitrite	10 000	ug/L	SDWA MCL	40 CFR 141
Nitrite	500	ug/L	Segment 4 & 5 Standard	Standard is 1-day average
Sulfate	250 000	ug/L	Colorado Water Quality Standard DW	5 CCR 1002 8 3 1 11
Volatile Organic Compounds				
1,1, Dichloroethane	59	ug/L	6 CCR 1007 3	Sec 268 43
1,2, Dichloroethene	70	ug/L	SDWA MCL	40 CFR 141
2 Butanone	280	ug/L	6 CCR 1007 3	Sec 268 43
2 Hexanone	50	ug/L	PQL	
4 Methyl 2 pentanone	140	ug/L	6 CCR 1007 3	Sec 268 43
Acetone	280	ug/L	6 CCR 1007 3	Sec 268 43
Benzene	1	ug/L	Colorado Water Quality Standard, HH,DW,DW&F	5 CCR 1002 8, 3 1 11
Chloromethane	5 7	ug/L	Colorado Water Quality Standard, DW&F	5 CCR 1002 8 3 1 11
Ethylbenzene	57	ug/L	RCRA LDR	40 CFR 268 40
Methylene Chloride	4 7	ug/L	Colorado Water Quality Standard, HH,DW&F	5 CCR 1002 8, 3 1 11
Tetrachloroethene	1	ug/L	PQL	
Toluene	1,000	ug/L	SDWA MCL	40 CFR 141
Total Xylenes	10,000	ug/L	SDWA MCL	40 CFR 141
Trichloroethene	2 7	ug/L	Colorado Water Quality Standard, HH,DW&F	5 CCR 1002 8, 3 1 11
Vinyl Acetate	5	ug/L	PQL	
Vinyl Chloride	2	ug/L	SDWA MCL	40 CFR 141

Analyte	ARAR/ TBC	Unit	Law/Regulation	Citation
Semivolatile Organic Compounds				
2 Methylnaphthalene	10	ug/L	PQL	
2,4-Dimethylphenol	36	ug/L	RCRA LDR	40 CFR 268.40
Acenaphthene	520	ug/L	Colorado Water Quality Standard, AQ,CH	5 CCR 1002.8, 3.1.11
Bis(2-ethylhexyl)phthalate	10	ug/L	PQL	
Dibenzofuran	10	ug/L	PQL	
Diethyl Phthalate	200	ug/L	RCRA LDR	40 CFR 268.40
Fluorene	10	ug/L	PQL	
Naphthalene	10	ug/L	PQL	
Phenanthrene	10	ug/L	PQL	

AG = Agricultural

SDWA = Safe Drinking Water Act

AQ = Aquatic

MCL = Maximum Contaminant Level

CH = Chronic

RCRA = Resource Conservation and Recovery Act

DW = Drinking Water

PQL = Practical Quantitation Limit

HH = Human Health

CFR = Code of Federal Regulations

DW&F = Drinking Water and Fish

CCR = Colorado Code of Regulations

LDR = Land Disposal Restrictions

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Table 3-15
Potential Chemical-Specific ARARs for Groundwater

Analyte	Potential ARAR	Unit	Law/Regulation	Citation
Metals				
Antimony	300	ug/L	PQL	
Arsenic	50	ug/L	SDWA MCL	40 CFR 141
Banum	1 000	ug/L	RCRA MCL	40 CFR 264 94
Beryllium	2	ug/L	PQL	
Cadmium	5	ug/L	SDWA MCL	40 CFR 141
Chromium	50	ug/L	RCRA MCL	40 CFR 264 94
Cobalt	10	ug/L	PQL	
Copper	1,300	ug/L	MCLG	40 CFR 141 50 52
Lead	50	ug/L	RCRA MCL	40 CFR 264 94
Manganese	200 (AG)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11
Mercury	2	ug/L	SDWA MCL	40 CFR 141
Nickel	100	ug/L	SDWA MCL	40 CFR 141
Selenium	20	ug/L	PQL	
Silver	70	ug/L	PQL	
Thallium	400	ug/L	PQL	
Tin	8 000	ug/L	PQL	
Vanadium	40	ug/L	PQL	
Zinc	2 000 (AG)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11
Radionuclides				
Americium 241	1 2 (DW)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Cesium 137	120 (DW)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Gross Alpha	15	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Plutonium 239, 240	1 2 (DW,a)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Radium 226	4 (DW)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Strontium 89,90	8	pCi/L	SDWA MCL	40 CFR 141
Tritium	20,000	pCi/L	SDWA MCL	40 CFR 141
Uranium 233 234	20 (DW b)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Uranium 235	24 (DW b)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Uranium 238	24 (DW b)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400 5
Total Uranium	40	pCi/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11
Indicators Water Quality Parameters				
Cyanide	200	ug/L	SDWA MCL	40 CFR 141
Fluoride	2,000 (DW)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11

Analyte	Potential ARAR	Unit	Law/Regulation	Citation
Nitrate/Nitrite	10,000	ug/L	SDWA MCL	40 CFR 141
Sulfate	250,000 (DW)	ug/L	Colorado Water Quality Standard	5 CCR 1002-8, 3 1 11
Volatile Organic Compounds				
1,1, Dichloroethane	1	ug/L	PQL	
1 1 Dichloroethene	7	ug/L	SDWA MCL	40 CFR 141
1,1,1, Trichloroethane	200	ug/L	SDWA MCL	40 CFR 141
1,1,2, Trichloroethane	1	ug/L	PQL	
1,2, Dichloroethene	0 (cis) 100 (trans)	ug/L	SDWA MCL	40 CFR 141
1 2 Dichloropropane	1	ug/L	PQL	
1,4 Dichlorobenzene	75	ug/L	SDWA MCL	40 CFR 141
2 Butanone	10	ug/L	PQL	
2 Hexanone	50	ug/L	PQL	
4 Methyl 2 pentanone	50	ug/L	PQL	
Acetone	100	ug/L	PQL	
Benzene	1 (HH DW DW&F)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11
Bromodichloromethane	1	ug/L	PQL	
Bromoform	4	ug/L	Colorado Basic Standard for Groundwater	5 CCR 1002-8, 3 1 11
Carbon Tetrachloride	1	ug/L	PQL	
Chlorobenzene	100 (HH DW, DW&F)	ug/L	Colorado Water Quality Standard	5 CCR 1002-8, 3 1 11
Chloroethane	5	ug/L	PQL	
Chloromethane	5 7 (DW&F)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11
Chloroform	6	ug/L	Colorado Basic Standard for Groundwater	5 CCR 1002 8 3 11
Ethylbenzene	680	ug/L	Colorado Basic Standard for Groundwater	5 CCR 1002-8, 3 1 11
Methylene Chloride	4 7 (HH DW&F)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11
Tetrachloroethene	1	ug/L	PQL	
Toluene	1,000	ug/L	SDWA MCL	40 CFR 141
Total Xylenes	10 000	ug/L	SDWA MCL	40 CFR 141
Trichloroethene	2 7 (HH, DW&F)	ug/L	Colorado Water Quality Standard	5 CCR 1002-8, 3 1 11
Trichlorofluoromethane	10	ug/L	PQL	
Vinyl Acetate	5	ug/L	PQL	
Vinyl Chloride	2	ug/L	SDWA MCL	40 CFR 141
Semivolatile Organic Compounds				
1,4 Dichlorobenzene	75	ug/L	SDWA MCL	40 CFR 141
2 Chloronaphthalene	10	ug/L	PQL	
2-Methylnaphthalene	10	ug/L	PQL	
2 4 Dimethylphenol	2,120 (AQ AC)	ug/L	Colorado Water Quality Standard	5 CCR 1002-8, 3 1 11
2,4,5 Trichlorophenol	10	ug/L	PQL	
4 Nitrophenol	10	ug/L	PQL	
Acenaphthene	520 (AQ, CH)	ug/L	Colorado Water Quality Standard	5 CCR 1002-8 3 1 11
Bis(2 ethylhexyl)phthalate	10	ug/L	PQL	
Dibenzofuran	10	ug/L	PQL	
Di n Butyl Phthalate	2 700 (HH, DW&F)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11

Analyte	Potential ARAR	Unit	Law/Regulation	Citation
Di-n-Octyl Phthalate	30	ug/L	PQL	
Diethyl Phthalate	23,000 (HH,DW&F)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11
Dimethylphthalate	313 (DW&F)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11
Fluorene	10	ug/L	PQL	
Naphthalene	10	ug/L	PQL	
Pentachlorophenol	50	ug/L	PQL	
Phenanthrene	10	ug/L	PQL	
Phenol	2,500 (AQ,CH)	ug/L	Colorado Water Quality Standard	5 CCR 1002 8, 3 1 11
Pesticides				
Aroclor 1232	50	ug/L	PQL	
Aroclor 1242	50	ug/L	PQL	

AG = Agricultural

DW = Drinking Water

HH = Human Health

AQ = Aquatic

AC = Acute

CH = Chronic (30-day)

DW&F = Drinking Water and Fish

a = f1 value of 1 E-03

b = f1 value of 5 E-02

SDWA = Safe Drinking Water Act

MCL = Maximum Contaminant Level

RCRA = Resource Conservation and Recovery Act

MCLG = Maximum Contaminant Level Goal

PQL = Practical Quantitation Limit

CFR = Code of Federal Regulations

CCR = Colorado Code of Regulations

Table 3-16
ARARs Comparison for Landfill Leachate

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
METALS										
ALUMINUM	10 - 30000	16/19	0	29	26900	---	---	2629	87	UG/L
ANTIMONY	0.05 - 60	4/18	0	14	60.4	---	A	20	300	UG/L
ARSENIC	0.7 - 10	8/16	0	1.4	3	B	---	3	50	UG/L
BARIUM	0.02 - 50000	19/19	1	297	1550	---	---	645	1000	UG/L
BERYLLIUM	0.2 - 5	2/18	0	0.2	1.4	---	JA	1	4	UG/L
CADMIUM	0.1 - 165	4/18	2	1	7.6	---	---	3	TVS	UG/L
CALCIUM	145 - 100000	19/19	0	126000	212000	---	---	151737	TVS	UG/L
CHROMIUM	2.4 - 27.5	7/18	0	2	29.6	---	---	9	50	UG/L
COBALT	0.02 - 50	10/18	2	2.7	19.1	B	---	11	50	UG/L
COPPER	2.4 - 25	8/18	0	2	94.9	---	---	12	TVS	UG/L
IRON	4.7 - 30000	19/19	0	61300	155000	---	---	81005	---	UG/L
LEAD	0.8 - 2000	14/18	0	15	11	---	V	5	TVS	UG/L
LITHIUM	2 - 2000	15/19	0	34	107	---	V	48	2500	UG/L
MAGNESIUM	0.1 - 200000	19/19	0	29300	49000	---	---	34868	---	UG/L
MANGANESE	1 - 10000	19/19	19	1320	2490	---	---	1623	50	UG/L
MERCURY	0.02 - 0.2	1/18	0	0.1	0.28	---	---	0.1	10	UG/L
MOLYBDENUM	5.7 - 200	6/18	0	4	28.5	B	---	21	---	UG/L
NICKEL	0.02 - 40	5/18	0	5	31	---	V	12	125	UG/L
POTASSIUM	10 - 200000	18/19	0	5000	11700	---	---	6511	---	UG/L
SELENIUM	1.1 - 5	2/18	0	1.1	7	W	---	2	17	UG/L
SILVER	2.6 - 25	8/18	0	2.7	16.7	---	---	5	50	UG/L
SODIUM	10 - 50000	19/19	0	57700	110000	---	V	71468	---	UG/L
STRONTIUM	3.5 - 10000	17/19	0	814	1370	---	---	920	---	UG/L
TIN	10 - 200	8/18	0	11	243	---	---	48	8000	UG/L
VANADIUM	3.2 - 10000	12/19	1	3.1	211	---	---	25	100	UG/L
ZINC	1.8 - 10000	19/19	16	857	16903	---	---	2974	2000	UG/L
PESTICIDES										
alpha-BHC	0.05 - 0.28	1/3	0	0	0	I	---	0.06	---	UG/L
RADIONUCLIDES										
AMERICIUM-241	0 - 0.013	16/16	0	-0.000404	0.02121	---	V	0.007	30	PC/L
CESIUM-137	0.47 - 1	14/14	0	-0.21	0.6057	J	---	0.15	3000	PC/L
GROSS ALPHA	1.5 - 7.4	8/8	0	0.8918	6.639	---	V	2.9	---	PC/L
GROSS BETA	1.69 - 11.5	8/8	6	3.753	17	---	V	10	---	PC/L
PLUTONIUM-238	0.01 - 0.01	2/2	0	-0.000465	0.00222	J	A	0.00088	30	PC/L
PLUTONIUM-239	0.003 - 0.003	1/1	0	0.009	0.009	---	---	0.009	30	PC/L
PLUTONIUM-239/240	0 - 0.013	16/16	0	0.001	0.01606	---	A	0.007	30	PC/L

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Table 3-16
ARARs Comparison for Landfill Leachate

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
RADIUM-226	0.03 - 0.03	1/1	0	0.58	0.58	—	A	0.58	100	PC/L
STRONTIUM-89,90	0.21 - 1	9/9	0	0.66	4.06	—	V	1.35	8	PC/L
STRONTIUM-90	0.2 - 0.59	3/3	0	0.5442	1.1	—	—	0.7	—	PC/L
TRITIUM	155 - 450	19/19	0	185.4	1500	—	A	393	1000	PC/L
URANIUM-233, 234	0.1 - 0.6	12/12	0	-0.0238	4.2	B	A	0.8	500	PC/L
URANIUM-235	0 - 0.6	12/12	0	-0.012	0.084	J	A	0.03	600	PC/L
URANIUM-238	0.086 - 0.6	12/12	0	0.03914	3.76	—	A	1	600	PC/L
SEMI-VOLATILE ORGANICS										
2,4-DIMETHYLPHENOL	10 - 10	1/5	0	3	3	J	A	5	36	UG/L
2-METHYLNAPHTHALENE	10 - 10	5/5	5	12	23	—	V	16	10	UG/L
4-METHYLPHENOL	10 - 10	3/5	0	2	4	J	—	4	—	UG/L
ACENAPHTHENE	10 - 10	5/5	0	2	3	J	A	3	520	UG/L
BIS(2-ETHYLHEXYL)PHTHALATE	10 - 12	1/5	0	2	2	J	A	5	10	UG/L
DIBENZOFURAN	10 - 10	5/5	0	1	2	J	A	1	10	UG/L
DIETHYL PHTHALATE	10 - 10	4/5	0	1	3	J	A	3	200	UG/L
FLUORENE	10 - 10	5/5	0	2	3	J	A	2	10	UG/L
NAPHTHALENE	10 - 10	5/5	5	14	22	—	V	18	10	UG/L
PHENANTHRENE	10 - 10	5/5	0	4	5	J	A	4	10	UG/L
VOLATILE ORGANICS										
1,1-DICHLOROETHANE	5 - 5	17/20	17	2	10	—	V	6	59	UG/L
1,2-DICHLOROETHENE	5 - 5	10/20	0	2	14	—	V	4	70	UG/L
2-BUTANONE	10 - 10	6/19	4	6	76	—	V	12	280	UG/L
2-HEXANONE	10 - 10	1/20	0	1	10	—	V	5	50	UG/L
4-METHYL-2-PENTANONE	10 - 10	5/20	1	10	87	J	A	11	140	UG/L
ACETONE	10 - 10	10/20	2	10	220	—	A	34	280	UG/L
BENZENE	5 - 5	11/20	4	1	2	J	—	2	1	UG/L
CARBON DISULFIDE	5 - 5	1/20	0	5	6	—	—	3	—	UG/L
CHLOROETHANE	10 - 10	15/20	15	10	57	—	V	22	—	UG/L
CHLOROMETHANE	10 - 10	2/20	1	4	7	J	A	5	57	UG/L
ETHYLBENZENE	5 - 5	19/20	0	1	18	—	—	13	57	UG/L
METHYLENE CHLORIDE	5 - 5	9/20	5	3	180	B	—	14	47	UG/L
O-XYLENE	5 - 5	3/4	0	5	8	—	—	6	—	UG/L
TETRACHLOROETHENE	5 - 5	2/20	0	1	1	J	—	21	1	UG/L
TOLUENE	5 - 5	19/20	0	5	88	—	—	38	1000	UG/L
TOTAL XYLENES	5 - 5	19/20	0	1	25	J	A	14	10000	UG/L
TRICHLOROETHENE	5 - 5	11/20	1	1	4	J	—	2	27	UG/L
VINYL ACETATE	10 - 10	1/19	1	10	49	—	—	72	5	UG/L

Table 3-16
ARARs Comparison for Landfill Leachate

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
VINYL CHLORIDE	10 - 10	5/23	5	3	1 ¹	----	V	5	2	UG/L
WATER QUALITY PARAMETERS										
BICARBONATE AS CaCO3	1000 - 10000	15/15	0	554000	705000	—	V	595800		UG/L
CARBONATE AS CaCO3	1000 - 10000	2/9	0	0	0	—	—	3889		UG/L
CHLORIDE	100.0 - 50000	14/14	0	1800.0	66300.0	—	V	53650		UG/L
CYANIDE	10 - 20	1/14	0	1.5	36.8	—	—	9	200	UG/L
DISSOLVED ORGANIC CARBON	1000 - 1000	4/4	0	14000	27000	—	JA	18750		UG/L
FLUORIDE	100.0 - 200.0	12/12	0	390.00	540.00	—	V	469.2	2000	UG/L
NITRATE/NITRITE	20.00 - 200.0	6/10	0	20.00	870.00	—	V	263	10000	UG/L
NITRITE	20.00 - 20.00	6/9	0	20.00	63.000	—	V	30.33	500	UG/L
OIL AND GREASE	200.0 - 11100.0	4/12	0	800.0	42100.0	—	V	7013		UG/L
ORTHOPHOSPHATE	10.00 - 200.0	3/10	0	50.00	150.00	—	—	60.9		UG/L
PH		5/5	0	6.8	7.3	—	—	7		PH
PHOSPHORUS	50.00 - 1000	9/9	0	95.000	1380	—	—	387		UG/L
SILICA	400.0 - 2000	3/3	0	7400.0	43000	—	—	19567		UG/L
SILICON	7.3 - 2000	13/13	0	7060	44000	—	—	13547		UG/L
SOLIDS, NONVOLATILE SUSPENDED	5000 - 5000	6/6	0	10000	199000	—	—	83167		UG/L
SULFATE	200.0 - 25000	5/14	0	200.0	29600.0	—	V	5084	250000	UG/L
TOTAL DISSOLVED SOLIDS	10000 - 10000	15/15	0	470000	870000	—	—	729333		UG/L
TOTAL ORGANIC CARBON	1000 - 1000	3/3	0	19000	24500.0	—	V	20833		UG/L
TOTAL SUSPENDED SOLIDS	4000 - 5000	12/12	0	10000	250000	—	—	144667		UG/L

Shaded analytes indicate mean result exceeds ARAR

All analytes are total analytes unless otherwise noted

Analytes with zero detections are not reported

For non-detects, one-half the detection limit is used in calculating the mean result

¹ For tetrachloroethene, the maximum detection equals the ARAR, the mean exceeds the ARAR because one-half detection limit

for non-detects exceeds the ARAR

² For vinyl acetate, one detection out of nineteen causes mean to exceed ARAR, suggests that one detection is outlier and should be discarded

Data Qualifiers

— = data qualifier field in database is blank.

B = for inorganics, reported value is < CRDL but > IDL (estimated value)

B = for organics, analyte is also detected in blank;

for common lab contaminants include as detection if blank result > 10 times detection limit,

for all other organics include if blank result > 5 times detection limit

B = for radionuclides, constituent also detected in blank whose concentration was > minimum detectable activity

I = organics, interference with target peak (estimated value)

Table 3-16
ARARs Comparison for Landfill Leachate

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
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J = for organics, MS data indicate presence of compound but below detection limit (estimated value)

U = for inorganics and organics, analyte analyzed but not detected at the quantitation limit

W = Inorganics post-digestion spike for GFAA analysis is out of control limits while sample absorbance is less than 50% of spike absorbance

Data Validation Codes

— = data validation field in database is blank

A = acceptable result

JA = acceptable result (for estimated value)

V = valid result

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Table 3-17
ARARs Comparison for Surface Water in the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
METALS										
ALUMINUM	10 - 200	16/22	5	30.4	271	—	—	75	87	UG/L
ANTIMONY	0.05 - 500	2/22	0	8	16.9	B	—	22	300	UG/L
ARSENIC	0.7 - 10	9/21	0	0.9	2.2	—	V	1	50	UG/L
BARIUM	0.02 - 200	22/22	0	16	250	—	V	172	1000	UG/L
BERYLLIUM	0.2 - 5	1/22	0	0.5	0.7	—	JA	1	4	UG/L
CADMIUM	0.1 - 5	1/22	0	1	2.1	—	JA	1	—	UG/L
CALCIUM	14.3 - 5000	22/22	0	3180	55000	—	V	39972	—	UG/L
CESIUM	5 - 2500	2/23	0	33	50	B	—	211	—	UG/L
CHROMIUM	2.4 - 20	2/22	0	2	10.9	—	—	3	50	UG/L
COPPER	2.1 - 25	8/22	0	2	16	—	JA	5	—	UG/L
IRON	4.3 - 100	22/22	0	16.3	1150	—	V	507	—	UG/L
LEAD	0.8 - 20	7/21	0	0.9	5.3	—	JA	2	—	UG/L
LITHIUM	2 - 100	20/21	0	7.7	109	—	—	79	2500	UG/L
MAGNESIUM	0.1 - 5000	22/22	0	4270	48300	—	—	39349	—	UG/L
MANGANESE	1 - 15	21/22	14	2.5	430	—	V	105	50	UG/L
MERCURY	0.2 - 0.2	3/22	0	0.1	0.54	—	V	0.1	10	UG/L
MOLYBDENUM	5.7 - 500	3/21	0	3	13.1	B	—	20	—	UG/L
NICKEL	0.02 - 40	14/22	0	6.3	22	—	V	10	125	UG/L
POTASSIUM	10 - 5000	22/22	0	1360	10900	—	V	8754	—	UG/L
SILICON	7.3 - 100	14/14	0	298	3670	—	V	2302	—	UG/L
SILVER	2.5 - 30	3/22	0	2	4	—	JA	3	50	UG/L
SODIUM	10 - 5000	22/22	0	19900	196000	—	—	161177	—	UG/L
STRONTIUM	2.3 - 200	21/21	0	44.9	598	—	—	476	—	UG/L
THALLIUM	0.1 - 10	2/21	0	1	7.4	—	JA	2	—	UG/L
TIN	10 - 1000	6/21	0	10	44.3	B	—	41	8000	UG/L
VANADIUM	2 - 50	5/22	0	2	9	B	—	4	100	UG/L
ZINC	1.8 - 20	19/22	0	4	105	—	—	17	2000	UG/L

RADIONUCLIDES

AMERICIUM-241	0 - 0.19	15/15	0	0.0005655	0.031	U	A	0.007	30	PC/L
CESIUM-137	0.23 - 1.16	11/11	0	-0.2323	0.1344	—	V	-0.06	3000	PC/L
GROSS ALPHA	2 - 8.68	11/11	0	-0.67	5	U	V	2	—	PC/L

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Table 3-17
ARARs Comparison for Surface Water in the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
GROSS BETA	2 57535 - 7 6	11/11	0	7 9	16	—	V	11		PC/L
PLUTONIUM-239	0 - 0 03	6/6	0	0	0 022	—	—	0 007	30	PC/L
PLUTONIUM-239/240	0 - 0 01	11/11	0	-0 000364	0 023	—	A	0 004	30	PC/L
RADIUM-226	0 211 - 0 211	1/1	0	0 23	0 23	—	V	0 23	100	PC/L
STRONTIUM-89,90	0 23 - 1	5/5	0	0 6635	1 924	—	A	1 4	8	PC/L
STRONTIUM-90	0 36 - 0 58	5/5	0	0 7084	1 208	—	V	1 02		PC/L
TRITIUM	160 - 460	20/20	0	-10	257 8	J	V	139	1000	PC/L
URANIUM-233-234	0 - 0 232	9/9	0	0 7626	1 594	—	V	1 1	500	PC/L
URANIUM-235	0 - 0 281	9/9	0	-0 01	0 3	—	A	0 1	600	PC/L
URANIUM-238	0 08 - 0 263	9/9	0	0 6996	1 964	—	A	1 1	600	PC/L

SEMIVOLATILE ORGANICS

BIS(2-ETHYLHEXYL)PHTHALATE	9 - 11	1/8	0	1	1	J	A	5	10	UG/L
DI-n-BUTYL PHTHALATE	9 - 11	1/8	0	1	1	J	A	5		UG/L

VOLATILE ORGANICS

ACETONE	10 - 10	1/21	0	6	12	B	—	6	280	UG/L
METHYLENE CHLORIDE	5 - 5	3/21	2	4	8	B	—	3	4 7	UG/L
VINYL ACETATE	10 - 10	1/20	1	10	80	—	—	9	5	UG/L

WATER QUALITY PARAMETERS

BICARBONATE AS CaCO3	1000 - 10000	16/16	0	213000	489000	—	V	391063		UG/L
CARBONATE	10000 - 10000	1/4	0	10000	15300 0	—	V	7575		UG/L
CARBONATE AS CaCO3	1000 - 10000	9/12	0	0	76500 0	—	V	28167		UG/L
CHLORIDE	200 0 - 25000	16/16	0	137000	190000	—	—	164875		UG/L
DISSOLVED ORGANIC CARBON	1000 - 2000	6/6	0	21900 0	32400 0	—	V	27250		UG/L
FLUORIDE	100 0 - 200 0	15/15	0	590 00	890 00	—	—	770 0	2000	UG/L
NITRATE	100 0 - 100 0	1/3	0	100 0	200 0	—	JA	100 0		UG/L
NITRATE/NITRITE	20 00 - 100 0	6/13	0	20 00	320 00	—	JA	80 0	10000	UG/L
OIL AND GREASE	200 0 - 7100 0	3/14	0	400 0	800 0	—	—	2289		UG/L
ORTHOPHOSPHATE	10 00 - 50 00	2/11	0	40 00	40 00	—	—	27 73		UG/L
pH		4/4	0	8 2	8 3	—	—	8 2		PH
PHOSPHORUS	50 00 - 1000	3/10	0	50 00	638	B	—	96		UG/L

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Table 3-17
ARARs Comparison for Surface Water in the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
SILICA	400 0 - 2000	5/5	0	2300 0	12000	—	—	6360		UG/L
SOLIDS, NONVOLATILE SUSPENDED	5000 - 5000	2/6	0	5000	12000	—	V	4667		UG/L
SULFATE	500 0 - 10000	16/16	0	7000	25600 0	—	V	16031	250000	UG/L
TOTAL DISSOLVED SOLIDS	10000 - 10000	16/16	0	230000	814000	—	V	705125		UG/L
TOTAL ORGANIC CARBON	1000 - 2000	6/6	0	26000	51000	—	—	33633		UG/L
TOTAL SUSPENDED SOLIDS	4000 - 5000	3/11	0	4000	4900000	—	—	448864		UG/L

Shaded analytes indicate mean result exceeds ARAR

All analytes are total analytes unless otherwise noted

Analytes with zero detections are not reported

For non-detects, one-half the detection limit is used in calculating the mean result

¹ For vinyl acetate, one detection out of nineteen causes mean to exceed ARAR, suggests that one detection is outlier and should be discarded

Data Qualifiers

-- = data qualifier field in database is blank.

B = for inorganics, reported value is < CRDL but > IDL (estimated value)

B = for organics, analyte is also detected in blank,

for common lab contaminants include as detection if blank result > 10 times detection limit,

for all other organics include if blank result > 5 times detection limit

J = for organics, MS data indicate presence of compound but below detection limit (estimated value)

U = for inorganics and organics, analyte analyzed but not detected at the quantitation limit

Data Validation Codes

— = data validation field in database is blank

A = acceptable result

JA = acceptable result (for estimated value)

V = valid result.

Table 3-18
ARARs Comparison for Downgradient Groundwater

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
0786 Summary Statistics										
RADIONUCLIDES										
GROSS ALPHA	9.2 - 9.2	1/1	1	53.9	53.9	—	V	53.9	15	PC/L
GROSS BETA	8.6 - 8.6	1/1	1	29.4	29.4	—	V	29.4	8	PC/L
TRITIUM	210 - 470	9/9	0	134.2	368	J	V	215	20000	PC/L
VOLATILE ORGANICS										
1,1-DICHLOROETHANE	0.1000 - 5	1/14	0	0.1	0.3	—	V	2	1	UG/L
CHLOROETHANE	0.4000 - 10	2/14	0	0.4	3	J	A	4	5	L
METHYLENE CHLORIDE	0.1000 - 5	4/14	0	0.1	3	J	A	2	47	U
WATER QUALITY PARAMETERS										
BICARBONATE AS CaCO3	1000 - 10000	5/5	0	690000	860000	—	V	778000		UG/L
CHEMICAL OXYGEN DEMAND	5000 - 10000	4/4	0	20000	55000.0	—	Y	41000		UG/L
CHLORIDE	200.0 - 5000	5/5	5	290000	370000	—	V	314000		UG/L
FLUORIDE	100.0 - 100.0	5/5	0	1200.0	1900.0	—	V	1540.0	2000	UG/L
NITRATE/NITRITE	20.00 - 100.0	5/9	0	20.00	1800.0	—	V	248.3	10000	UG/L
SILICA	400.0 - 400.0	2/2	0	7200.0	9600.0	—	V	8400.0		UG/L
SULFATE	2000 - 5000	5/5	0	170000	250000	—	V	210000	250000	UG/L
TOTAL DISSOLVED SOLIDS	10000 - 14000	5/5	0	1400000	1700000	—	V	1560000		UG/L
TOTAL ORGANIC CARBON	1000 - 5000	4/4	0	13800.0	22000	—	V	18375		UG/L
TOTAL SUSPENDED SOLIDS	4000 - 5000	5/5	0	43000	150000	—	V	77200		UG/L
pH		1/1	0	7.1	7.1	—	—	7.1		PH
4087 Summary Statistics										
RADIONUCLIDES										
AMERICIUM-241	0.01 - 0.01	1/1	0	0.002	0.002	—	A	0.002	12	PC/L
PLUTONIUM-239/240	0 - 0	1/1	0	0.006	0.006	—	A	0.006	12	PC/L
TRITIUM	253 - 650	5/5	0	0	260.8	J	V	169.4	20000	PC/L
URANIUM-233-234	0.36 - 0.36	1/1	0	20.09	20.09	—	A	20.09	20	PC/L
URANIUM-235	0.31 - 0.31	1/1	0	0.5933	0.5933	—	A	0.5933	24	PC/L
URANIUM-238	0.25 - 0.25	1/1	0	13.23	13.23	—	A	13.23	24	PC/L
VOLATILE ORGANICS										
METHYLENE CHLORIDE	0.2000 - 5	2/8	0	0.2	2	J	—	2	47	UG/L
WATER QUALITY PARAMETERS										
BICARBONATE AS CaCO3	1000 - 10000	5/5	0	220000	400000	—	—	331200		UG/L
CARBONATE AS CaCO3	1000 - 10000	2/4	0	1000	12000	—	V	5375		UG/L

Indicator
subscripts

Table 3-18
ARARs Comparison for Downgradient Groundwater

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
CHEMICAL OXYGEN DEMAND	5000.0 - 10000	2/2	0	10000	14000	—	V	12000		UG/L
CHLORIDE	200.0 - 5000	4/4	0	50000	99000	—	—	81425		UG/L
FLUORIDE	100.0 - 100.0	5/5	1	1500.0	3400.0	—	—	2050	2000	UG/L
NITRATE/NITRITE	20.00 - 100.0	4/5	0	20.00	644	—	Y	305	10000	UG/L
ORTHOPHOSPHATE	50.00 - 50.00	2/2	0	52.000	130.00	—	JA	91.00		UG/L
SILICA	400.0 - 400.0	2/2	0	5600.0	9000	—	—	7300		UG/L
SULFATE	2000 - 5000	5/5	5	280000	770000	—	—	522000	250000	UG/L
TOTAL DISSOLVED SOLIDS	10000 - 14000	5/5	0	850000	1400000	—	—	1120000		UG/L
TOTAL ORGANIC CARBON	1000 - 1000	2/2	0	7500.0	10500.0	—	Y	9000.0		UG/L
TOTAL SUSPENDED SOLIDS	4000 - 5000	5/5	0	19000	39000	—	V	30800		UG/L

4287 Summary Statistics

METALS										
ALUMINUM	200 - 200	2/2	0	2060	3080	—	—	2570		UG/L
ARSENIC	10 - 10	1/2	0	19	19	B	—	1	50	UG/L
BARIUM	200 - 200	2/2	0	79.6	94.5	B	—	87.1	1000	UG/L
CALCIUM	5000 - 5000	2/2	0	77800	95400	—	—	86600		UG/L
CHROMIUM	10 - 10	2/2	0	69	9.5	B	—	8.2	50	UG/L
COPPER	25 - 25	1/2	0	67	9.4	B	—	6.4	1300	UG/L
IRON	100 - 100	2/2	0	1860	2890	—	—	2375		UG/L
LEAD	3 - 3	2/2	0	11	2.6	B	—	1.9	50	UG/L
LITHIUM	100 - 100	2/2	0	13.5	17	B	V	15		UG/L
MAGNESIUM	5000 - 5000	2/2	0	11300	12200	—	—	11750		UG/L
MANGANESE	15 - 15	2/2	0	58.7	59.8	E	—	59.3	200	UG/L
MOLYBDENUM	200 - 200	1/2	0	3	4	B	—	3		UG/L
NICKEL	40 - 40	2/2	0	7.1	8.4	B	—	7.8	100	UG/L
POTASSIUM	5000 - 5000	2/2	0	1290	1310	B	V	1300		UG/L
SILICON	100 - 100	1/1	0	13300	13300	N	JA	13300		UG/L
SILVER	10 - 10	1/2	0	2	3.2	B	—	2	70	UG/L
SODIUM	5000 - 5000	2/2	0	23200	27900	—	—	25550		UG/L
STRONTIUM	200 - 200	2/2	0	412	421	—	—	417		UG/L
TIN	200 - 200	1/2	0	11.5	11.5	B	—	12	8000	UG/L
VANADIUM	50 - 50	2/2	0	24.3	32.1	B	—	28.2	40	UG/L
ZINC	20 - 20	2/2	0	21.9	28.9	E	—	25.4	2000	UG/L

RADIONUCLIDES

AMERICIUM-241	0 - 0.01	4/4	0	0.00107	0.011	—	JA	0.005	1.2	PCI/L
CESIUM-137	0.6 - 0.82	2/2	0	-0.0334	0.38	—	A	0.17	120	PCI/L
PLUTONIUM-239/240	0 - 0.01	4/4	0	0.0002529	0.004	—	A	0.002	1.2	PCI/L

Table 3-18
ARARs Comparison for Downgradient Groundwater

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
STRONTIUM-89/90	0.25 - 0.25	1/1	0	0.49	0.49	-	A	0.49	8	PCI/L
TRITIUM	216.7 - 520	6/6	0	-84.9	390	-	-	128	20000	PCI/L
URANIUM-233, 234	0.61 - 0.61	1/1	0	4.078	4.078	-	A	4.078	20	PCI/L
URANIUM-235	0.74 - 0.74	1/1	0	0.7962	0.7962	-	A	0.7962	24	PCI/L
URANIUM-238	0.61 - 0.61	1/1	0	3.683	3.683	-	A	3.683	24	PCI/L

VOLATILE ORGANICS

METHYLENE CHLORIDE	0.1000 - 5	1/9	0	0.1	1	J	V	2	4.7	UG/L
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HAZARDOUS WASTE SUBSISTANCE PARAMETERS

BICARBONATE AS CaCO3	1000 - 10000	8/8	0	210000	352000	-	V	265796		UG/L
CARBONATE AS CaCO3	1000 - 10000	1/6	0	760.00	760.00	B	V	1293		UG/L
CHEMICAL OXYGEN DEMAND	5000 - 10000	3/3	0	10660.00	21000	-	V	14887		UG/L
CHLORIDE	200.0 - 5000	7/7	0	12000	17775.000	-	V	14239		UG/L
FLUORIDE	100.0 - 100.0	8/8	0	400.0	800.0	-	V	618.8	2000	UG/L
NITRATE/NITRITE	20.00 - 100.0	6/7	0	40.00	200.0	-	V	94.3	10000	UG/L
ORTHOPHOSPHATE	10.00 - 50.00	5/5	0	10.00	150.00	-	JA	44.00		UG/L
SILICA	400.0 - 400.0	2/2	0	5500.0	7200.0	-	V	6350.0		UG/L
SULFATE	2000 - 5000	8/8	0	33000	79221.000	-	V	48253	250000	UG/L
TOTAL DISSOLVED SOLIDS	10000 - 14000	8/8	0	280000	374000	-	V	337250		UG/L
TOTAL ORGANIC CARBON	1000 - 5000	4/4	0	5000	9100.0	-	V	6603		UG/L
TOTAL SUSPENDED SOLIDS	4000 - 5000	8/8	0	88000	442000	-	V	213750		UG/L
pH		1/1	0	7.6	7.6	-	-	7.6		PH

53194 Summary Statistics

RADIONUCLIDES										
AMERICIUM-241	0.00436 - 0.00436	1/1	0	0.006443	0.006443	-	Y	0.006443	1.2	PCI/L
PLUTONIUM-238	0.00314 - 0.00314	1/1	0	0.002318	0.002318	J	Y	0.002318		PCI/L
PLUTONIUM-239/240	0.0125 - 0.0125	1/1	0	0.004633	0.004633	J	Y	0.004633	1.2	PCI/L
TRITIUM	384 - 384	1/1	0	14.34	14.34	J	Y	14.34	20000	PCI/L

B206789 Summary Statistics

METALS										
ALUMINUM	16 - 200	7/7	0	217	635	-	V	385		UG/L
ANTIMONY	17 - 60	1/7	0	14.00	58	B	Y	18	300	UG/L
ARSENIC	2 - 10	1/7	0	1	2.7	-	V	1	50	UG/L
BARIUM	9 - 200	4/7	0	16.1	22	B	Y	16	1000	UG/L
CALCIUM	17 - 5000	7/7	0	151000	167000	-	V	158000		UG/L
CESIUM	20 - 1000	1/6	0	23	45	B	Y	122		UG/L

Table 3-18
ARARs Comparison for Downgradient Groundwater

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
CHROMIUM	3-10	2/7	0	2 00	17	—	JA	4	50	UG/L
COPPER	2-25	1/7	0	2	8	B	Y	4	1300	UG/L
IRON	5-100	7/7	0	238	527	—	V	383		UG/L
LEAD	1-5	2/7	0	1	12	B	V	1	50	UG/L
LITHIUM	2-100	7/7	0	186	225	—	Y	207		UG/L
MAGNESIUM	36-5000	7/7	0	40700	44900	—	V	42500		UG/L
MANGANESE	1-15	5/7	0	28	97	—	V	63	200	UG/L
NICKEL	10-40	1/7	0	3	111	B	Y	5	100	UG/L
POTASSIUM	620-5000	6/7	0	3640	3760	B	V	3489		UG/L
SELENIUM	0-5	7/7	7	488.00	815	+	JA	665	20	UG/L
SILICON	13-100	6/6	0	5950.00	7170	—	V	6447		UG/L
SILVER	4-10	1/7	0	2	1090	N	JA	3	70	UG/L
SODIUM	21-5000	7/7	0	139000.00	148000	—	V	144429		UG/L
STRONTIUM	1-200	7/7	0	1360.00	1560	—	V	1446		UG/L
THALLIUM	2-10	1/7	0	1	1	B	V	1	400	UG/L
TIN	18-200	1/7	0	10	192	B	V	12	8000	UG/L
VANADIUM	3-50	3/7	0	290	89	BE	JA	5	40	UG/L
ZINC	3-20	4/7	0	91	527	—	JA	193	2000	UG/L

RADIONUCLIDES

AMERICIUM-241	0.01 - 0.01	1/1	0	-0.433	-0.433	J	—	-0.433	12	PCI/L
PLUTONIUM-239/240	0.01 - 0.01	2/2	0	0.001103	0.004	—	A	0.003	12	PCI/L
RADIUM-226	0.06 - 0.5	2/2	0	0.35	0.52	—	A	0.44	4	PCI/L
TRITIUM	211.7 - 840	10/10	0	-138	230	U	V	21	20000	PCI/L

SEMI-VOLATILE ORGANICS

BIS(2-ETHYLHEXYL)PHTHALATE	10 0000 - 10 0000	1/2	0	3	3	J	A	4	10	UG/L
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VOLATILE ORGANICS

ACETONE	10 - 10	1/17	0	9	11	B	—	5	100	UG/L
BENZENE	0.1000 - 10	1/19	0	0.1	0.1	J	—	2	1	UG/L
METHYLENE CHLORIDE	0.1000 - 10	1/19	0	0.1	3	J	—	2	4.7	UG/L

WATER QUALITY PARAMETERS

BICARBONATE AS CaCO3	1000 - 10000	14/14	0	135000	190000	—	V	168909		UG/L
CARBONATE AS CaCO3	1000 - 10000	4/9	0	0	1430.00	B	V	1103		UG/L
CHEMICAL OXYGEN DEMAND	5000 - 10000	3/4	0	10000	12000	—	V	9500		UG/L
CHLORIDE	200.0 - 10000	14/14	0	59000	89200.0	—	V	71474		UG/L
FLUORIDE	100.0 - 200.0	13/13	0	300.0	500.0	—	—	399.2	2000	UG/L

Indicator

Table 3-18
ARARs Comparison for Downgradient Groundwater

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
NITRATE/NITRITE	20.00 - 2800.0	18/18	0	3000	9700.0	—	—	6583	10000	UG/L
ORTHOPHOSPHATE	10.00 - 50.00	3/6	0	10.00	30.00	—	—	19.17	—	UG/L
SILICA	400.0 - 2000	6/6	0	5500.0	25000	—	JA	9200	—	UG/L
SODIUM FLUORIDE	100.0 - 100.0	1/1	0	520.00	520.00	—	V	520.00	—	UG/L
SODIUM SULFATE	20000 - 20000	1/1	0	524000	524000	—	V	524000	—	UG/L
SULFATE	2000 - 100000	13/13	13	560000	900000	—	V	643600	250000	UG/L
TOTAL DISSOLVED SOLIDS	5000 - 14000	14/14	0	1140000	1300000	—	JA	1206500	—	UG/L
TOTAL ORGANIC CARBON	1000 - 5000	7/7	0	3000	5190.00	—	V	3891	—	UG/L
TOTAL SUSPENDED SOLIDS	4000 - 5000	13/14	0	5000	590000	—	—	61321	—	U'
pH		1/1	0	7.7	7.7	—	—	7.7	—	—

B206889 Summary Statistics

RADIONUCLIDES										
TRITIUM	267.586638 - 660	9/9	0	-164.49541	130.4	J	—	16	20000	PCI/L
URANIUM-233, -234	0 - 0	1/1	0	49.32	49.32	—	A	49.32	20	PCI/L
URANIUM-235	0.07 - 0.07	1/1	0	2.62	2.62	—	A	2.62	24	PCI/L
URANIUM-238	0.07 - 0.18	2/2	0	29.81	35.45	—	A	32.63	24	PCI/L

VOLATILE ORGANICS

ACETONE	10 - 100	1/13	0	10	24	B	—	10	100	UG/L
BENZENE	0.1000 - 5	1/18	0	0.1	0.5	J	A	2	1	UG/L
CARBON TETRACHLORIDE	0.2000 - 5	2/18	0	0.2	7.11	—	Y	3	1	UG/L
ETHYLBENZENE	0.2000 - 5	1/18	0	0.2	0.3	J	A	2	680	UG/L
METHYLENE CHLORIDE	0.1000 - 5	2/18	1	0.1	8	B	—	3	47	UG/L
TETRACHLOROETHENE	0.1000 - 5	1/18	0	0.1	0.769	—	Y	2	1	UG/L
TOLUENE	0.1000 - 5	1/18	0	0.1	3	J	A	2	1000	UG/L
TOTAL XYLENES	0.5 - 5	1/16	0	0.5	3	J	A	2	10000	UG/L
TRICHLOROETHENE	0.1000 - 5	1/18	0	0.1	1.43	—	Y	2	2.7	UG/L

WATER QUALITY PARAMETERS

BICARBONATE AS CaCO3 — <i>subsequent</i>	1000 - 10000	2/2	0	186000	200000	—	V	193000	—	UG/L
CHEMICAL OXYGEN DEMAND	5000 - 10000	2/2	0	20000	22560.00	—	V	21280	—	UG/L
CHLORIDE	200.0 - 25000	2/2	1	239000	460000	—	V	349500	—	UG/L
FLUORIDE	100.0 - 100.0	2/2	0	450.00	500.0	—	V	475.0	2000	UG/L
NITRATE/NITRITE	20.00 - 200000	11/11	11	82000	290000	—	JA	157275	10000	UG/L
ORTHOPHOSPHATE	10.00 - 10.00	1/1	0	30.00	30.00	—	V	30.00	—	UG/L
SOLIDS, NONVOLATILE SUSPENDED	5000 - 5000	1/1	0	29000	29000	—	JA	29000	—	UG/L
SULFATE	2000 - 250000	2/2	2	1420000	1600000	—	V	1510000	250000	UG/L
TOTAL DISSOLVED SOLIDS	10000 - 10000	2/2	0	3580000	3700000	—	V	3630000	—	UG/L

Table 3-18
ARARs Comparison for Downgradient Groundwater

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
TOTAL ORGANIC CARBON	1000 - 5000	3/3	0	7370.00	8940.00	-	V	8303.3		UG/L
TOTAL SUSPENDED SOLIDS	4000 - 4000	1/1	0	29000	29000	-	V	29000		UG/L
B206989 Summary Statistics										
RADIONUCLIDES										
TRITIUM	236.92 - 420	5/5	0	-141	107.12	-	V	-17	2000	PCI/L
VOLATILE ORGANICS										
METHYLENE CHLORIDE	0.1000 - 5	3/15	2	0.1	8	B	-	2	4.7	UG/L
TOLUENE	0.1000 - 5	1/16	0	0.1	1	J	-	2	1000	UG/L
WATER QUALITY PARAMETERS										
BICARBONATE AS CaCO ₃ - subscript	10000 - 10000	1/1	0	390000	390000	-	V	390000		UG/L
CHLORIDE	5000 - 5000	1/1	0	170000	170000	-	V	170000		UG/L
FLUORIDE	100.0 - 100.0	1/1	0	230.00	230.00	-	V	230.00	2000	UG/L
NITRATE/NITRITE	20.00 - 20.00	5/5	5	36000	72000	-	V	49600	10000	UG/L
SULFATE	5000 - 5000	1/1	1	2600000	2600000	-	V	2600000	250000	UG/L
TOTAL DISSOLVED SOLIDS	14000 - 14000	1/1	0	5100000	5100000	-	V	5100000		UG/L
TOTAL SUSPENDED SOLIDS	5000 - 5000	1/1	0	38000	38000	-	V	38000		UG/L
B207089 Summary Statistics										
METALS										
ALUMINUM	200 - 200	5/6	0	141	733	-	V	395		UG/L
ANTIMONY	60 - 60	1/6	0	8	66.8	-	JA	21	300	UG/L
BARIUM	200 - 200	5/6	0	27.5	42.9	B	V	32	1000	UG/L
CADMIUM	5 - 5	2/6	0	1	2.4	B	V	1	5	UG/L
CALCIUM	5000 - 5000	6/6	0	136000	149000	-	V	141000		UG/L
CHROMIUM	10 - 10	3/6	0	2.5	18	-	V	7	50	UG/L
COPPER	25 - 25	1/6	0	3.5	6.2	B	JA	4	1300	UG/L
IRON	100 - 100	6/6	0	124	731	-	V	392		UG/L
LITHIUM	100 - 100	6/6	0	119	138	-	V	128		UG/L
MAGNESIUM	5000 - 5000	6/6	0	40600	44100	-	V	41833		UG/L
MANGANESE	15 - 15	6/6	0	14.1	109	-	V	43	200	UG/L
MOLYBDENUM	200 - 200	1/6	0	2	7.3	B	V	4		UG/L
NICKEL	40 - 40	2/6	0	4	7.5	B	JA	6	100	UG/L
POTASSIUM	5000 - 5000	6/6	0	6270	6730	-	V	6492		UG/L
SELENIUM	5 - 5	1/6	0	1	1	B	JA	1	20	UG/L
SILICON	100 - 100	3/3	0	2720	3610	-	V	3053		UG/L
SILVER	10 - 10	1/5	0	2	2.2	B	V	2	70	UG/L

Table 3-18
ARARs Comparison for Downgradient Groundwater

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
SODIUM	5000 - 5000	5/5	0	442000	465000	—	V	452200		UG/L
STRONTIUM	200 - 200	5/5	0	1640	1870	—	V	1730		UG/L
TIN	200 - 200	1/5	0	10	20.2	B	V	12	8000	UG/L
VANADIUM	50 - 50	3/5	0	5	11.5	B	JA	7	40	UG/L
ZINC	20 - 20	3/5	0	11.3	33.4	—	V	20.8	2000	UG/L

RADIONUCLIDES

AMERICIUM-241	0 - 0.030	17/17	0	0	0.012	—	A	0.005	1.2	PCI/L
CESIUM-134	2.21 - 2.21	1/1	0	0.64	0.64	—	—	0.64		PCI/L
CESIUM-137	0.74 - 2.37	8/8	0	-0.498	0.4298	J	A	0.0	120	PCI/L
GROSS ALPHA	4.8 - 74.07	2/2	1	0	19	—	Y	10	15	PCI/L
GROSS BETA	10 - 21.82	2/2	1	3.46	13	—	Y	8	8	PCI/L
PLUTONIUM-238	0.01 - 0.01	1/1	0	0.01164	0.01164	—	—	0.01164		PCI/L
PLUTONIUM-239/240	0 - 0.087	19/19	0	-0.000272	0.009	J	V	0.002	1.2	PCI/L
RADIUM-226	0.096 - 0.096	1/1	0	0.64	0.64	B	Y	0.64	4	PCI/L
STRONTIUM-89/90	0.38 - 1.6	3/3	0	-0.14	0.31	—	A	0.06	8	PCI/L
STRONTIUM-90	0 - 0	1/1	0	1.31	1.31	—	—	1.31		PCI/L
TRITIUM	0 - 820	20/20	0	-78.34	400	U	—	103	20000	PCI/L
URANIUM-233 - 234	0 - 0.36	2/2	0	2.8	4.25	—	—	3.5	20	PCI/L
URANIUM-235	0 - 0.25	2/2	0	0.062	0.351	—	—	0.217	24	PCI/L
URANIUM-238	0 - 0.37	2/2	0	1.5	1.58	—	—	1.5	24	PCI/L

VOLATILE ORGANICS

BENZENE	0.1000 - 5	1/18	0	0.1	0.1	J	—	2	1	UG/L
METHYLENE CHLORIDE	0.1000 - 5	4/19	2	0.1	12	B	—	3	47	UG/L
TOLUENE	0.1000 - 5	1/19	0	0.1	0.2	J	—	2	1000	UG/L

WATER QUALITY PARAMETERS

AMMONIA	30.0 - 100.0	5/12	0	80.00	214.000	—	Y	82		UG/L
BICARBONATE AS CaCO ₃	1000 - 10000	18/18	0	38000	670000	—	V	322558		UG/L
CARBONATE AS CaCO ₃	1000 - 10000	5/14	0	0	1500.0	B	V	934		UG/L
CHEMICAL OXYGEN DEMAND	0 - 10000	8/11	0	4800.0	20970.00	—	Y	8374		UG/L
CHLORIDE	200.0 - 100000	17/17	17	447000	530000	—	V	496106		UG/L
CYANIDE	5.00 - 100.0	2/17	0	1	5.6000	B	V	9	200	UG/L
FLUORIDE	0 - 100.0	18/18	0	300.0	750.00	—	Y	369.6	2000	UG/L
NITRATE/NITRITE	20.00 - 2600.0	17/18	0	665	2400.0	—	JA	1101	10000	UG/L
ORTHOPHOSPHATE	10.00 - 50.00	5/14	0	6.000	60.00	—	V	16.50		UG/L
SILICA	400.0 - 400.0	6/6	0	2600.0	3700.0	—	V	2883		UG/L
SPECIFIC CONDUCTIVITY	1.00 - 1.00	2/2	0	3105.2	3110	—	Y	3108		UMHOS/CM

Table 3-18
ARARs Comparison for Downgradient Groundwater

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
SULFATE	1000.00 - 100000	18/18	18	440000	19000000	—	—	1612462	250000	UG/L
TOTAL DISSOLVED SOLIDS	5000 - 14000	18/18	0	1900000	2100000	—	—	1975111		UG/L
TOTAL ORGANIC CARBON	1000 - 1000	9/11	0	190.00	5590.00	—	V	2438		UG/L
TOTAL SUSPENDED SOLIDS	4000 - 5000	16/18	0	4000	87000	—	V	26750		UG/L
pH	0.10 - 0.10	2/2	0	7.7	7.73	—	Y	7.7		PH

Analyte mean results which exceed ARARs

Data Qualifiers

- = data qualifier field in database is blank
- + = correlation coefficient for matrix spike analysis is less than 0.995 (estimated value)
- B = for inorganics, reported value is < CRDL but > IDL (estimated value)
- B = for organics, analyte is also detected in blank for common lab contaminants include as detection if blank result > 10 times detection limit for all other organics include if blank result > 5 times detection limit
- B = for radionuclides, constituent also detected in associated blank whose concentration was greater than CRDL and/or minimum detectable activity (estimated value)
- E = for inorganics, value is an estimate due to interference (estimated value)
- J = for inorganics, value > IDL but control sample analysis not within control limits (estimated value)
- J = for organics, MS data indicate presence of compound but below detection limit (estimated value)
- N = for inorganics, spiked sample recovery is not within control limits (estimated value)
- U = Organics and inorganics, analyte analyzed but not detected at the quantitation limit

Data Validation Codes

- = data qualifier field in database is blank
- A = acceptable result
- JA = acceptable result (for estimated value)
- V = valid result
- Y = analytical results in validation process

Table 3-19
Location-Specific ARARs Identified

Law/Regulation	Citation	Description	ARAR Designation	Comments
Federal Laws				
Endangered Species Act	16 USC § 1538, 50 CFR Part 17	Ensures that remedial/removal actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify their critical habitats	Applicable	Listed endangered species found around Rocky Flats include the bald eagle. Category 2 species found at Rocky Flats include the ferruginous hawk and Preble's meadow jumping mouse. The Rocky Flats area supports habitat for many other endangered and category 2 species but none have been found.
Bald and Golden Eagle Protection Act	16 USC § 668a, 50 CFR § 22	Contains permitting requirements to take (kill or destroy habitat) possess or transport bald (American) and golden eagles, their nests, or their eggs anywhere in the United States	Applicable	General applicability. Bald eagles have been identified migrating through Rocky Flats. Some habitat at Rocky Flats is suitable for nesting.
Fish and Wildlife Coordination Act	16 USC § 661 et seq	Requires consultation by the federal department or agency proposing or authorizing any modification of any stream or other water body and adequate provision for protection of fish and wildlife resources	Applicable	Applicable because possible remedial action (e.g. reducing the size of the pond as a result of the extent of the landfill cap) may affect wildlife that depend upon the pond.
Wetlands Assessment	Executive Order 11990, 40 CFR Part 6, Appendix A	Federal agencies must prevent, to the extent possible, the adverse impacts of destroying or modifying wetlands and must prevent direct or indirect support of new construction in wetlands if there is a practicable alternative	Applicable	Applicable because riparian areas around the East Landfill Pond have been identified as wetland areas.
Clean Water Act	33 CFR §§ 320.330, 40 CFR § 230	Action to dispose of dredge and fill material in waters of the United States is prohibited without a permit. Under CERCLA § 121(e), no permitting is required for onsite actions, however consultation with the U.S. Army Corps of Engineers remains important.	Applicable	Action to drain the East Landfill Pond is a dredging operation within the parameters of the Clean Water Act. It remains unclear whether the East Landfill Pond is considered waters of the U.S.
State Laws				
Colorado Nongame Endangered, or Threatened Species Conservation Act	CRS 33-2-101 to -107	Establishes requirements for protection of wildlife	Applicable	Parallels the federal Endangered Species Act. In addition to the species identified above, Rocky Flats contains two species of concern in Colorado: forktip threesawn and toothcup.

Definitions

ARAR applicable or relevant and appropriate requirement

CERCLA Comprehensive Environmental Response, Compensation and Liability Act

CFR Code of Federal Regulation

186

CRS Colorado Revised Statutes
USC United States Code

187

Table 3-20
Federal and State Action-Specific ARARs

Law/Regulation	Citation	Description	ARAR Designation	Comments
Federal Laws				
Resource Conservation and Recovery Act	42 USC § 9621 <i>et seq</i>			
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable possibility of adverse effects on health or the environment	Relevant and appropriate	Not applicable because it applies to ongoing operations at solid waste disposal facilities (OU 7 is now regulated as an interim status facility under 40 CFR 265). Relevant and appropriate to identifying criteria that may pose a reasonable probability of adverse effect on human health or the environment.
Criteria for Municipal Solid Waste Landfills	40 CFR Part 258	Establishes minimum criteria for municipal solid waste landfills to ensure protection to human health and the environment. Subpart E: Ground Water Monitoring and Corrective Action. Subpart F: Closure and Post Closure Care, and Appendix 1 and 2 are all identified as potential ARARs.	Relevant and appropriate	Not applicable because OU 7 is not a municipal site. Relevant and appropriate because OU 7 contains wastes typical for a municipal landfill. Identified sections relate to post-closure environmental issues.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards that define the acceptable management of hazardous waste for owners and operators of facilities that treat, store, and dispose of hazardous waste.	Relevant and appropriate	CDH directs that monitoring and post-closure care requirements are relevant and appropriate for detecting contaminant levels near the East Landfill Pond.
Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 265	Establishes minimum national standards that define the acceptable management of hazardous waste during the period of interim status and until certification of final closure, or if the facility is subject to post-closure until responsibilities are fulfilled.	Applicable	Applicable because OU 7 is undergoing closure as an interim status RCRA facility pending closure.
Land Disposal Restrictions	40 CFR Part 268	Establishes restrictions for the land disposal of hazardous wastes.	Relevant and appropriate	Not applicable because OU 7 remediation does not "place" hazardous wastes outside the area of contamination. It is relevant and appropriate because the type of place regulated is sufficiently similar.
Clean Water Act	33 USC §§ 1251-1376			
Discharge of Stormwater	40 CFR § 122.21 and § 122.26	Controls point source discharges of stormwater associated with industrial activity, including requirements for pollution prevention plans.	Relevant and appropriate	Relevant and appropriate because industrial activity includes landfills.
Criteria and Standards for the National Pollutant Discharge Elimination System	40 CFR Part 125 Subpart K	Requires that best management practices be maintained by the operator of a system that discharges pollutants directly into the environment and requires that point source discharges be monitored to ensure compliance with effluent discharge limits.	Applicable	Applicable through the NPDES Federal Facility Compliance Agreement (FFCA CWA 90-1).

Law/Regulation	Citation	Description	ARAR Designation	Comments
Atomic Energy Act	42 USC § 2011 et seq			
Standards for Protection Against Radiation	10 CFR Part 20	Establishes minimum standards for radioactive waste disposal	Relevant and appropriate	Not applicable because Rocky Flats is not a NRC licensed facility. It is relevant and appropriate for its standards to protect the public from radiation exposure and radionuclide contamination of waters and soils.
DOE Orders				
General Environmental Protection Program	DOE Order 5400.1	Specifies environmental protection standards applicable to DOE operations	Applicable	Contains broad requirements for environmental monitoring
Environment, Safety and Health Program for Department of Energy Operations	DOE Order 5480.1B	Specifies responsibility of DOE and conditions under which operations are to be curtailed due to risks	Applicable	Applicable as a potential ARAR because onsite remedial activities need to conform to its restrictions
Environmental Protection, Safety and Health Protection Standards	DOE Order 5480.4	Specifies environment and safety requirements for facility construction, operation and decommissioning including requirements applicable to DOE and subcontractors	Applicable	Applicable as general standards under which remedial activities must be conducted
Radiation Protection of the Public and the Environment	DOE Order 5400.5	Specifies compliance of DOE and its contractors under Atomic Energy Act radiation protection requirements	Applicable	Contains compliance guidelines for managing residual radioactive material. Basic dose limits, guidelines and authorized limits for allowable levels of residual radioactive material and control requirements for radioactive wastes and residues
Radioactive Waste Management	DOE Order 5480.2A	Specifies environmental protection requirements for management of low-level waste	Applicable	Includes general performance objectives and monitoring requirements
State Laws				
Colorado Solid Waste Disposal Sites and Facilities Act	CRS 30-20-100.5 et seq			
Colorado Solid Waste Disposal Sites and Facilities Regulations	6 CCR 1007.2	Establishes solid waste disposal criteria including the collection, storage, treatment, utilization, processing and final disposition of solid wastes	Relevant and appropriate	Not applicable because OU 7 is not regulated under state standards for solid waste disposal. Closure monitoring, and post-closure maintenance requirements are relevant and appropriate to the Present Landfill because they apply to facilities that are sufficiently similar to OU 7.
Hazardous Waste Management Regulations Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines those solid wastes that are subject to regulation as hazardous wastes	Applicable	Characterization of waste at the landfill may determine the selection of a remedy
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes the methodology for determining if a solid waste is a hazardous waste	Applicable	Characterization of waste at the landfill may determine the selection of a remedy
Soil Erosion Dust Blowing Act	CRS 35-72-101 et seq	Creates an actionable duty to all real property owners in the state to prevent soil from blowing to neighboring lands	Applicable	Intended to apply to all lands in the state of Colorado

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Definitions

§	section	applicable or relevant and appropriate requirement
ARAR		
CCR	Colorado Code of Regulation	
CDH	Colorado Department of Health	
CFR	Code of Federal Regulation	
CRS	Colorado Revised Statutes	
CWA	Clean Water Act	
DOE	U S Department of Energy	
FFCA	Federal Facility Compliance Agreement	
NPDES	National Pollutant Discharge Elimination System	
NRC	Nuclear Regulatory Commission	
OU	operable unit	
RCRA	Resource Conservation and Recovery Act	
USC	United States Code	

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Table 3-21
Regulatory and Technical Guidance to be Considered

Guidance Source	Citation	Description	ARAR Designation	Comments
A Guide to Delisting of RCRA Wastes for Superfund Remedial Responses	OSWER 9347 3-09FS September 1990	Circumstances delisting wastes may be appropriate and the procedures for delisting a RCRA hazardous waste as part of a Superfund remedial response	TBC	This guidance document lists maximum allowed concentrations (MACs) for various hazardous constituents, above which solids containing those wastes are not eligible for delisting. Although the guidance states that these levels are not to be used for setting cleanup levels, MACs may be relevant and appropriate for defining an outer boundary where soil contamination may not exceed that level.
Land Disposal Restrictions for Newly Identified and Listed Hazardous Wastes and Hazardous Soil	58 FR 48092, 48097 (1993)	Proposed numerical treatment standards for organic and metal constituents in soil	TBC	As it is a proposed regulation, it is at most a TBC. Its use is relevant and appropriate for setting chemical-specific standards for soil. If promulgated, it will become an ARAR.
Air Emissions from Municipal Solid Waste Landfills	56 FR 24468 (1991)	Proposed threshold standards for NMOCs at municipal solid waste landfills	TBC	Relevant and appropriate for determining acceptable NMOC limits before triggering the need for additional treatment.
Presumptive Remedy for CERCLA Municipal Landfill Sites	EPA Directive No 9355 0-49FS	Containment is the presumptive remedy for CERCLA municipal landfills	TBC	OU 7 is largely a landfill containing a combination of solid and hazardous wastes consistent with characterization as a municipal landfill.

Definitions

ARAR applicable or relevant and appropriate requirement
CERCLA Comprehensive Environmental Response Compensation and Liability Act
EPA U S Environmental Protection Agency
FR Federal Register
MAC maximum allowed concentration
NMOC non-methane organic compound
OSWER Office of Solid Waste and Emergency Response
OU operable unit
RCRA Resource Conservation and Recovery Act
TBC guidance or recommendation to be considered

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Table 2 - Estimated Gas Emission Rates Required to Exceed HAP De Minimis Levels

Chemical	CAS No	Reporting Bin	Scenario 3 De Minimis Level (lbs/year)	Highest Sampled Concentration (ppm)	Gas emission rate required to exceed de minimis emission level (liter/day)	Avg of Five Highest Readings (ppm)	Gas emission rate required to exceed de minimis emission level (liter/day)
methylene chloride (dichloromethane)	75-09-2	A	250	3,438	90 45	2,849 20	109 14
1,2-DCE (ethylene dichloride)	107-06-2	A	250	680	457 29	295 00	1,054 10
hydrogen sulfide	7783-06-4	A	250	79	3,936 19	17 32	17,953 75
1,1,1-TCA (methyl chloroform)	71-55-6	C	5,000	1,304	4,769 31	392 20	15,857 16
2-butanone (MEK)	78-93-3	C	5,000	26	239,199 16	13 52	459,998 38
xylenes	1330-20-7	C	5,000	9 1	683,426 16	6 73	924,372 49
toluene	108-88-33	C	5,000	3 8	1,636,625 81	2 74	2,269,773 02
TCE (trichloroethylene)	79-01-6	C	5,000	1 29	4,821,068 28	0 98	6,320,302 93
acetone	67-64-1	not listed	--	80	NA	37 40	NA

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Table X - Estimated NMOC Emissions from Rocky Flats OU7 Landfill

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Year	Waste Volume (cy)	k (1/yr)	Lo (m3/mg)	M _i (Mg)	t _i (yrs)	CNMOC (ppmv)	Conv factor	NMOC (Mg/yr) (7)	NMOC (Mg/yr) based on average loading to the facility (8)
1968	7,300	0.02	230	6,555	29	8,000	4E-09	0.0148	
1969	7,300	0.02	230	6,555	28	8,000	4E-09	0.0145	
1970	7,300	0.02	230	6,555	27	8,000	4E-09	0.0142	
1971	7,300	0.02	230	6,555	26	8,000	4E-09	0.0139	
1972	7,300	0.02	230	6,555	25	8,000	4E-09	0.0137	
1973	7,300	0.02	230	6,555	24	8,000	4E-09	0.0134	
1974	8,615	0.02	230	7,737	23	8,000	4E-09	0.0155	
1975	8,615	0.02	230	7,737	22	8,000	4E-09	0.0152	
1976	8,615	0.02	230	7,737	21	8,000	4E-09	0.0149	
1977	8,615	0.02	230	7,737	20	8,000	4E-09	0.0146	
1978	8,615	0.02	230	7,737	19	8,000	4E-09	0.0143	
1979	8,615	0.02	230	7,737	18	8,000	4E-09	0.0140	
1980	8,615	0.02	230	7,737	17	8,000	4E-09	0.0137	
1981	8,615	0.02	230	7,737	16	8,000	4E-09	0.0135	
1982	8,615	0.02	230	7,737	15	8,000	4E-09	0.0132	
1983	8,615	0.02	230	7,737	14	8,000	4E-09	0.0129	
1984	8,615	0.02	230	7,737	13	8,000	4E-09	0.0127	
1985	8,615	0.02	230	7,737	12	8,000	4E-09	0.0124	
1986	8,615	0.02	230	7,737	11	8,000	4E-09	0.0122	
1987	8,615	0.02	230	7,737	10	8,000	4E-09	0.0119	
1988	8,615	0.02	230	7,737	9	8,000	4E-09	0.0117	
1989	8,615	0.02	230	7,737	8	8,000	4E-09	0.0115	
1990	8,615	0.02	230	7,737	7	8,000	4E-09	0.0112	
1991	8,615	0.02	230	7,737	6	8,000	4E-09	0.0110	
1992	12,000	0.02	230	10,776	5	8,000	4E-09	0.0151	
1993	12,000	0.02	230	10,776	4	8,000	4E-09	0.0148	
1994	12,000	0.02	230	10,776	3	8,000	4E-09	0.0145	
1995	12,000	0.02	230	10,776	2	8,000	4E-09	0.0142	
1996	12,000	0.02	230	10,776	1	8,000	4E-09	0.0139	
1997	12,000	0.02	230	10,776	0	8,000	4E-09	0.0136	
total (5)	270,877			243,247				0.41	53.66
total (6)	539,000			484,022					106.77

- (1) Based on 20 cy received per day for 365 days/year from 1968 to 1978 (OU7 Work Plan p 4-7)
(2) Based on total 160,000 cy averaged annually from 1974 to 1986 (OU7 Work Plan p 4-7)
(3) Based on EG&G monitoring from November 1992 to April 1993 -- 1,000 cy per month (OU7 Work Plan p 4-8)
(4) Based on one ton/cubic yard, 898 Megagrams/ton
(5) Based on annual loadings calculated
(6) Based on total volume of material expected in landfill at closure, including fill (OU7 Work Plan p 4-8)
(7) Formula (a)(1)(i) from 56 FR 24503
(8) Formula (a)(1)(ii) from 56 FR 24503

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Table 3-25
Comparison of PCOC Concentrations at Seep to MACs

Analyte	Maximum Detection	Units	UCL ₉₅	Maximum Allowable Concentration (MAC)	Maximum Detection > MAC?
METALS					
ANTIMONY	60	UG/L	27 52	63	no
BARIUM	1,550	UG/L	742 52	6,300	no

SEMIVOLATILES					
2,4-DIMETHYLPHENOL	3	UG/L	5 45	26 24	no
BIS(2-ETHYLHEXYL)PHTHALATE	2	UG/L	6 05	18 93	no
DIETHYL PHTHALATE	3	UG/L	4 05	189,000	no
FLUORENE	3	UG/L	2 92	12 62	no
NAPHTHALENE	22	UG/L	21 26	63,090	no
PHENANTHRENE	5	UG/L	4 92	12 62	no

VOLATILES					
1,1-DICHLOROETHANE	10	UG/L	7 20	2 524	yes
ACETONE	220	UG/L	52 88	25,240	no
BENZENE	2	UG/L	2 14	31 66	no
CARBON DISULFIDE	6	UG/L	2 98	25,240	no
ETHYLBENZENE	18	UG/L	14 42	4,410	no
TETRACHLOROETHENE	1	UG/L	2 53	31 55	no
TOLUENE	88	UG/L	47 55	12,020	no
TOTAL XYLENES	25	UG/L	16 80	63,090	no
TRICHLOROETHENE	4	UG/L	2 44	21 55	no
VINYL CHLORIDE	11	UG/L	5 92	12 62	no

All concentrations are for total analytes

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sec 3 #6 doc*

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Ingestion Inhalation
Dermal Contact and
Physical Hazards

Dust Volatilization
and Landfill Gas

Surface Water
Diversion Ditch

Inhalation Explosion

Landfill Gas

Soil Cover

Surface
Runoff

Ingestion Dermal Contact
Inhalation and External
Irradiation

Ingestion

Pond
Wellands

Ingestion

Seepage

Monitoring
Wells

Sediments

Leachate
Seepage

Groundwater
Baseflow

Leaching

Landfill Waste

Volatilization

Weathered Bedrock

Unweathered Bedrock

Aluvium

— Exposure Route

→ Release Mechanism

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Golden Colorado

Conceptual Site Model for Assessment of Risks at OU 7

IM/IRA DD Operable Unit No. 7
July 1995

Figure 3-1

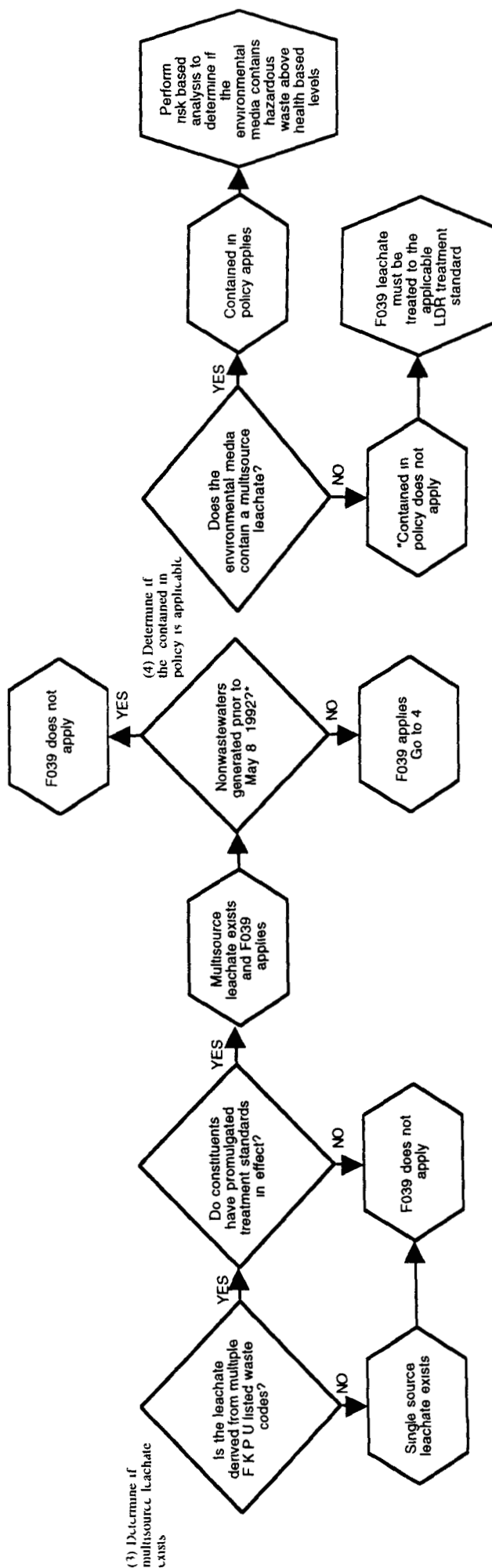
Not to scale

195

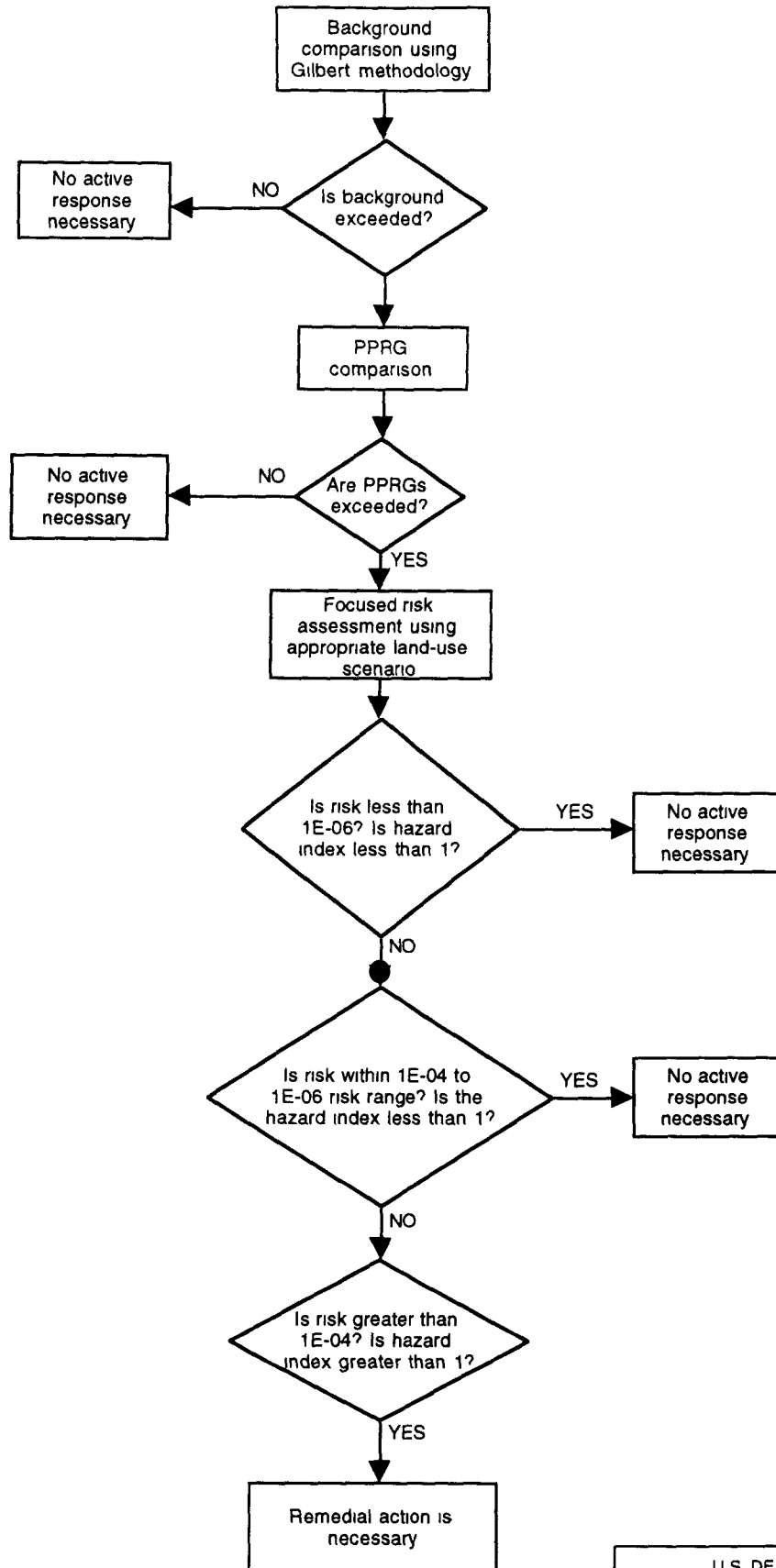
```

graph TD
    Start([Start]) --> D1{Does solid waste exist?}
    D1 -- YES --> D2{Does hazardous waste exist?}
    D1 -- NO --> E1[/Not a solid waste  
Therefore not a hazardous waste/]
    D2 -- YES --> D3{Has the hazardous waste been land disposed?}
    D2 -- NO --> E2[/Not a hazardous waste  
Therefore not a hazardous leachate/]
    D3 -- YES --> E3[/Land disposal has occurred  
Go to 2/]
    D3 -- NO --> E4[/Land disposal has not occurred/]
    E3 --> D4{Has liquid percolated through or drained from land disposed waste?}
    D4 -- YES --> E5[/Leachate exists by derived from rule  
Go to 3/]
    D4 -- NO --> E6[/Not a leachate/]
    E5 --> End([End])
    E6 --> End
    E1 --> End
    E2 --> End
    E3 --> End
    E4 --> End
    E5 --> End
    E6 --> End

```



Definitions	
Leachate	Any liquid including any suspended components in the liquid that has percolated or drained from hazardous waste (6CCR 1007.3 Part 260.10)
F039 (multi source leachate)	Leachate (liquids that have percolated through land disposed wastes) resulting from the disposal of more than one restricted waste classified as hazardous under Subpart D (6 CCR 1007.3 Part 261.31)
Land disposal	Placement of hazardous waste in a landfill surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave (6 CCR 1007.3 Part 268.2)
Contained in policy	Any environmental media (e.g. groundwater, soil) contaminated with a hazardous waste must be managed as a hazardous waste until the media no longer contains hazardous waste
Nonwastewater	Any liquid that was previously granted an extension until May 6, 1992 for the F039 nonwastewater



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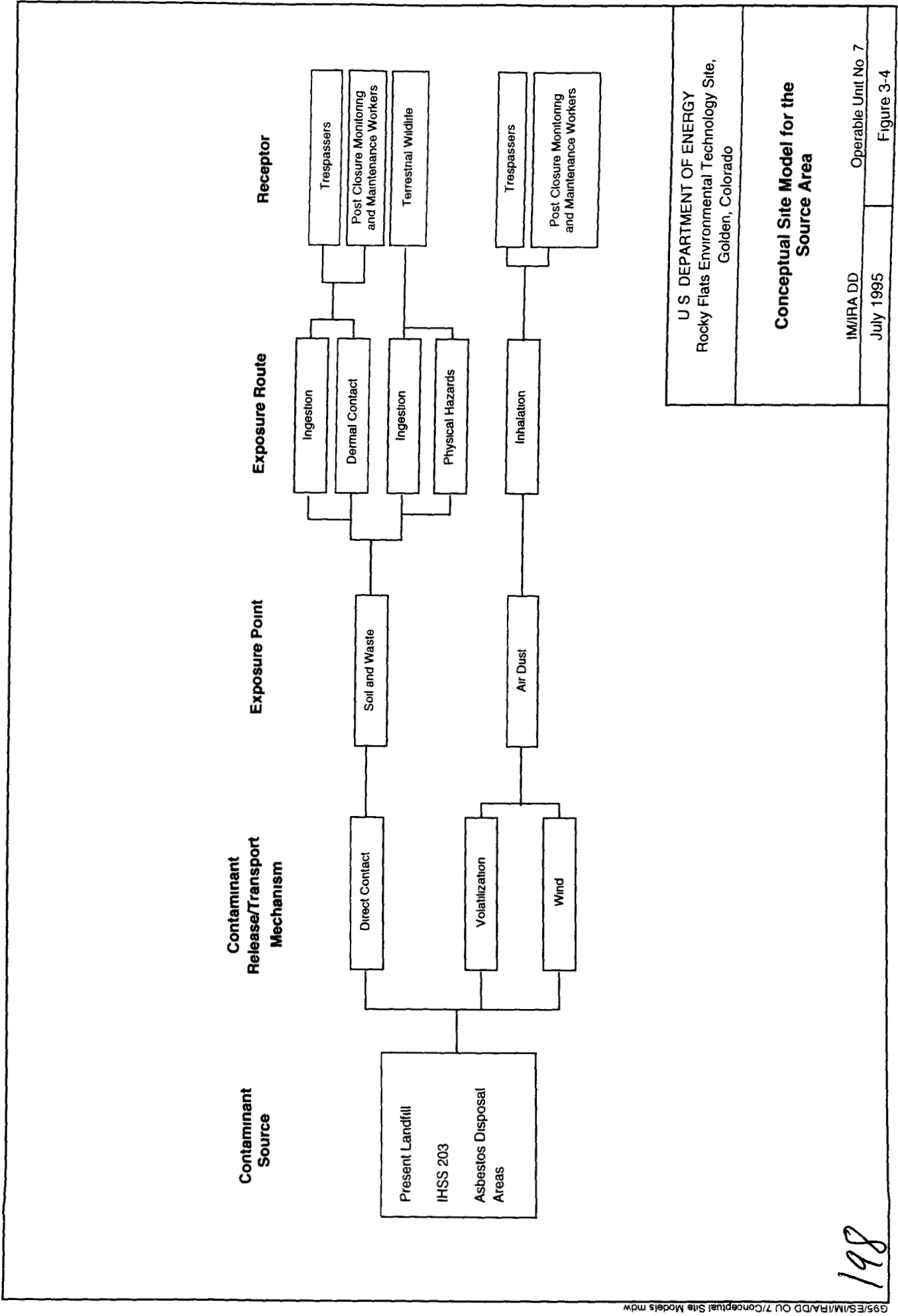
**Remediation Determination for
Environmental Media**

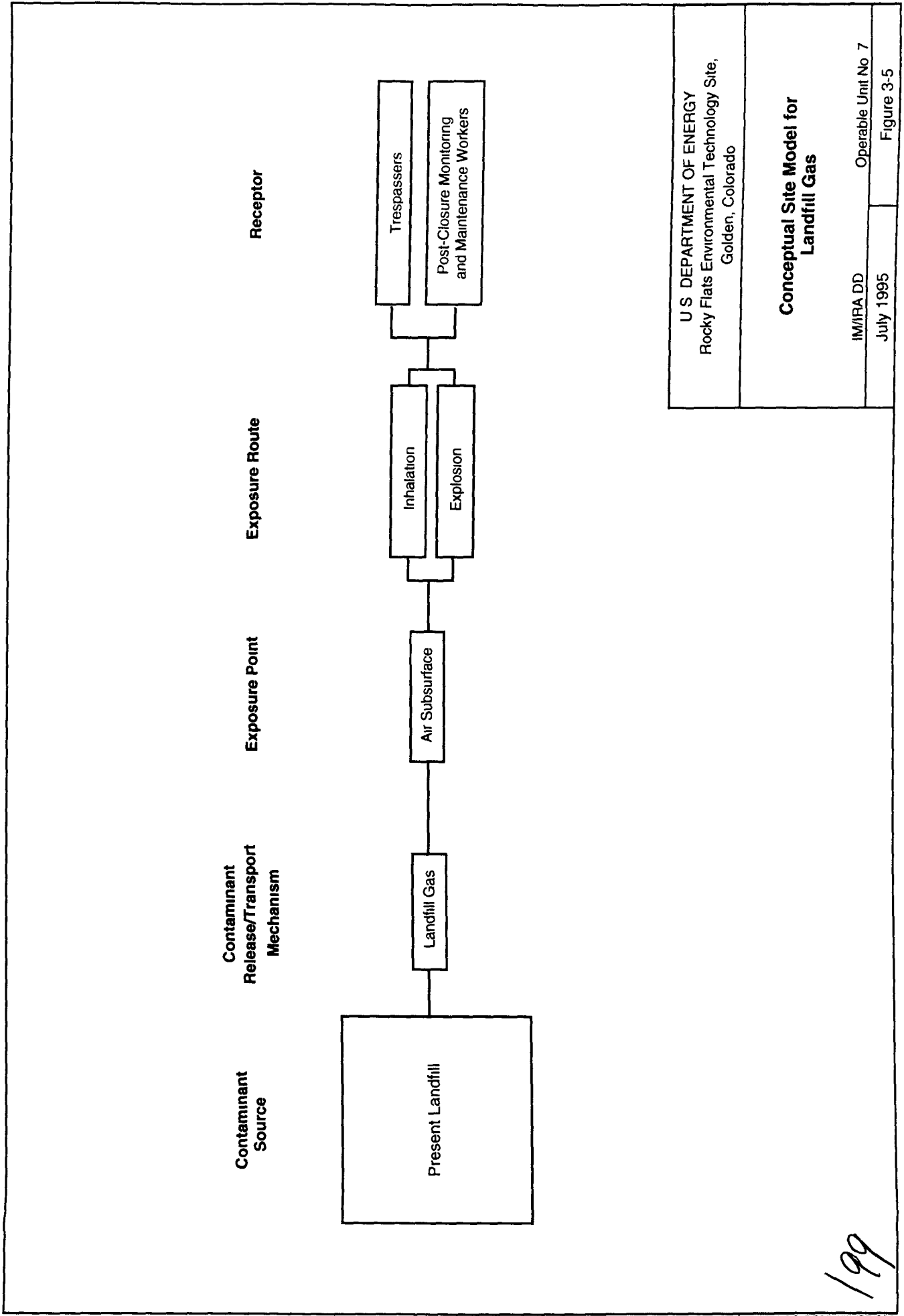
IM/IRA DD

Operable Unit No. 7

July 1995

Figure 3-3



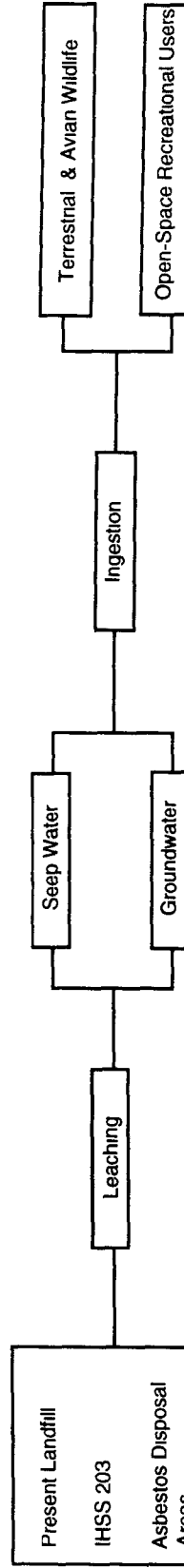


U S DEPARTMENT OF ENERGY Rocky Flats Environmental Technology Site, Golden, Colorado	
IMIRA DD July 1995	Operable Unit No 7 Figure 3-5

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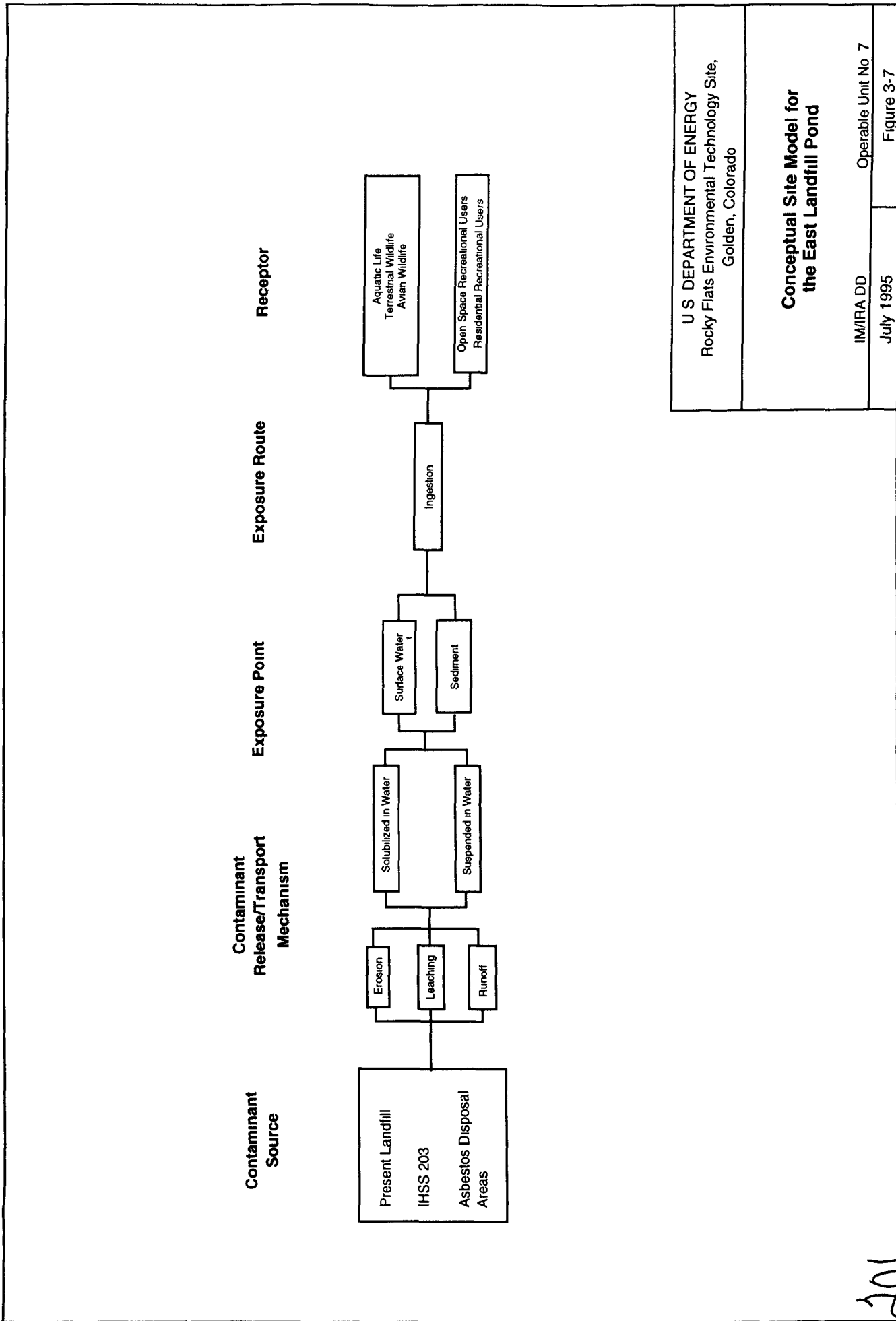
Contaminant Source Contaminant Release/Transport Mechanism Exposure Point Exposure Route Receptor



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Golden, Colorado

**Conceptual Site Model for
Landfill Leachate at the Seep**

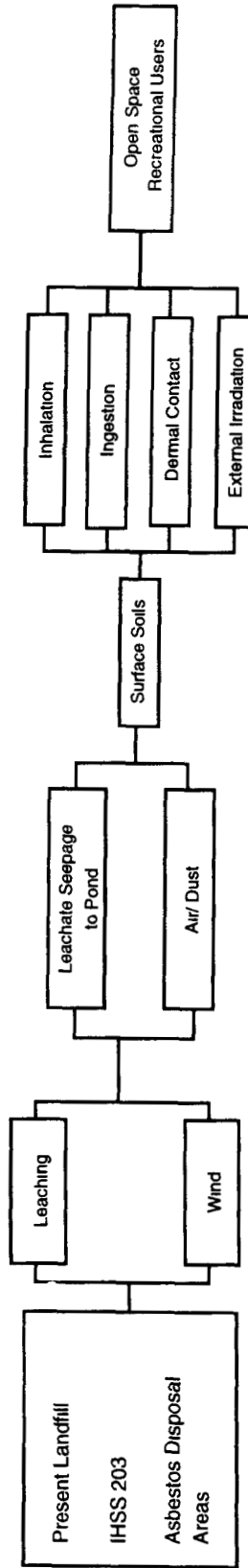
IM/IRA DD Operable Unit No 7
July 1995 Figure 3-6



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Contaminant Source Contaminant Release/Transport Mechanism Exposure Point Exposure Route Receptor



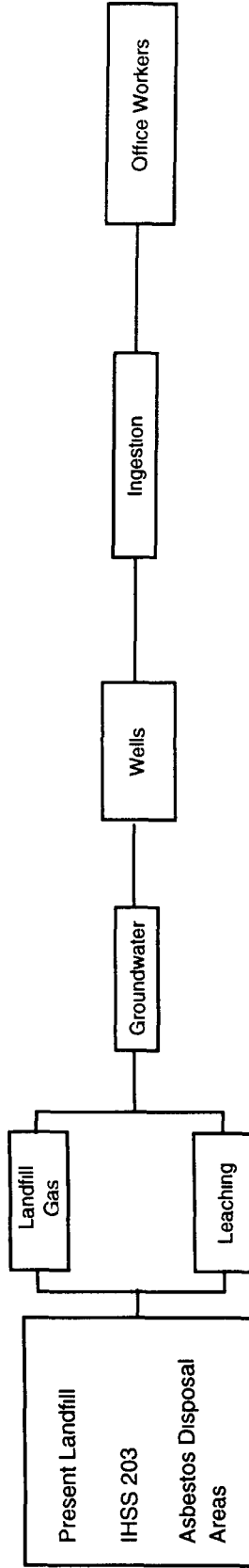
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Rocky Flats Environmental Technology Site,
Golden, Colorado

Conceptual Site Model for Surface Soils in Spray Evaporation Areas

IM/IRA DD Operable Unit No. 7

July 1995 Figure 3-8

Contaminant Source Contaminant Release/Transport Mechanism Exposure Point Exposure Route Receptor



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Golden, Colorado

**Conceptual Site Model for
Groundwater Downgradient of the Source**

IM/IRA DD Operable Unit No 7
July 1995 Figure 3-9

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4. Identification and Screening of Technologies

This section documents the screening of technologies identified in the Technology Literature Research (EG&G 1994d). The screening process is based on three criteria: effectiveness, implementability, and cost.

4.1 General Response Actions

General Response Actions (GRAs) are general categories of activities used in remediation of contamination. The GRAs are no action, institutional controls, containment, removal/collection, disposal, and treatment. For each GRA, there are a number of potentially effective technologies for each medium at a specific site.

Under the presumptive remedy, certain GRAs have been determined to be most effective for CERCLA landfills. The two primary components of the presumptive remedy at OU 7 are containment of the landfill mass and collection and/or treatment of the landfill gas (EPA 1993a). Institutional controls are also recommended to supplement engineering technologies.

4.2 Identification and Screening of Technologies.

For each GRA identified under the presumptive remedy, there are a number of applicable technologies. The technically feasible technologies identified in the Technology Literature Research (EG&G 1994d) are evaluated relative to each other and screened in order to reduce the number of technologies used in preparation of the alternatives. This section summarizes this process.

4.2.1 Screening Process

In the screening process, technologies are evaluated relative to each other in terms of effectiveness, implementability, and cost. For this screening, effectiveness in protecting human health and the environment is given the greatest weight, and cost is used only to distinguish between two similarly rated technologies.

The effectiveness criteria include the degree to which a technology meets RAOs and ARARs, reduces toxicity, mobility, or volume through treatment, affords long-term protection, and minimizes residual risks and short-term impacts.

The implementability evaluation criteria include a determination of the technical and administrative feasibility of implementing the technology. Technical feasibility is used in the Technology Literature Research (EG&G 1994d) as an initial screen of technology types to eliminate those that were clearly ineffective or unworkable at the

site This evaluation places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits, community acceptance, and the availability of necessary equipment and skilled workers to implement the technology

Cost plays a limited role in the screening of technologies, it is used primarily to distinguish between two similarly rated technologies At this stage, the cost analyses are based on engineering judgment of the relative capital and operation and maintenance (O&M) costs

4.2.2 No Action

Although no action is not identified in the presumptive remedy as a GRA, it is always identified for the purpose of establishing a baseline for comparison Under no action, no preventative or corrective actions are taken

4.2.3 Institutional Controls

Institutional controls are methods by which federal, state and local governments or private citizens can limit exposure to contamination Most institutional controls take the form of use or access restrictions These may include simple physical actions such as fencing and warning signs or more complex regulatory actions such as implementing zoning controls, water use and deed restrictions

Each of the four institutional control technologies evaluated in Table 4-1, land use restrictions, access restrictions, water use controls, and public education, are retained All the technologies are effective and implementable and are included in the alternative development In addition, all of the technologies are already in place to some extent at the site

4.2.4 Containment

Containment actions restrict contact with and migration of contaminants Under the presumptive remedy, a landfill cap is the preferred containment technology Table 4-2 identifies three types of capping technologies a native soil cover, a single barrier cap, and a composite barrier cap Although composite barrier caps are ranked most effective, each cap is considered fully effective for certain site conditions Therefore, each of the three caps are modeled and evaluated in further detail in the alternative analysis As discussed in Section 2.3, the groundwater is presently contained by the groundwater intercept system and East Landfill Pond dam

4 2 5 Landfill Gas Collection

Collection response actions partially or completely remove contaminants from the original location. In landfills, gas is generally collected in order to protect the integrity of the cap. The landfill gas may also be collected prior to treatment (see Section 4 2 6).

Table 4-3 shows the evaluation of various types of passive and active collection systems. Both types of systems have been used in municipal landfills for gas collection and control. However, hazardous waste landfills have rarely used active system because they normally do not produce much gas. Although active gas extraction wells have been used in municipal landfills, they have had only limited success at being effective in collecting gas over a large area. Due to the variability in the waste composition, the design of a gas extraction well is difficult.

A passive gas extraction system is applicable to sites where offsite migration is limited and gas will be forced to collect in a blanket collection system. The conditions at OU 7 are very conducive to a passive gas collection system. The base of the landfill is located in a low permeability unit of weathered bedrock, and a majority of the perimeter of the landfill is or will be surrounded by a slurry wall. The slurry wall will prevent any offsite migration of gas and force the gas to be collected under the cover. All of the cover options being considered for OU 7 also will contain a low permeability component that will help to contain migrating gas and facilitate collection with a passive system. For these reasons, a passive gas collection system has been selected for use at OU 7.

Venting trenches are eliminated because they are considered the least effective and the most difficult to implement at OU 7. Both passive vents and permeable layers are carried forward.

4 2 6 Landfill Gas Treatment

Treatment response actions reduce the toxicity, mobility and/or volume of the contaminants through physical or chemical alteration. Table 4-4 shows the evaluation of landfill gas treatment systems.

As discussed in Section 3, it is not anticipated that landfill gas will exceed ARARs. However, maintenance actions (such as the slurry wall) and the proposed closure of the landfill may affect gas generation by limiting the migration of gas and decreasing the infiltration of surface water. Due to the unknown impacts on the gas concentration and flow rates as a result of these actions, it is unknown at this time what, if any, treatment will be required.

Based on these uncertainties, it is recommended that a gas collection system be installed which would allow for post-closure monitoring of the composition, concentration and flow rate until treatment requirements can be determined. The collection system should also be designed to be compatible with gas treatment units should they be required.

The passive gas collection system will have vent pipes at various locations across the cover. The vent pipes will extend through the cover and will be logical points for monitoring emissions from the landfill. If required, the vent pipes could be routed directly to a treatment system to reduce emissions from the landfill.

4.3 Results of Screening

Based on the screening presented in this section, the following technologies will be considered in alternative development:

Institutional Controls (included in all alternatives)

- use restrictions
- access restrictions
- water use controls
- public education

Containment

- native soil cover
- single barrier cap
- composite barrier cap

Gas Collection and Treatment

- permeable layer
- vents
- post-closure gas monitoring and treatment if needed

Table 4-1
Evaluation of Remedial Technologies
Institutional Controls

Response Action	Description	Effectiveness	Implementability	Cost	Comments
Institutional Controls					
<ul style="list-style-type: none"> • Land Use Restrictions <ul style="list-style-type: none"> - Deed Restrictions - Zoning Ordinances 	Legal restrictions on future use of the site				Some restrictions already in place
	Restrictive covenants on deed to the landfill property. May include limitations on excavation and basements in contaminated areas	Low	High	Low	
	Zoning change, administrative consent order, or judicial order prohibiting certain land uses	Moderate	Moderate	Moderate	
<ul style="list-style-type: none"> • Access Restrictions <ul style="list-style-type: none"> - Fencing - Written Warnings 	Physical restrictions to limit access to site				Some restrictions already in place, including a barbed-wire fence around the site and a 4 ft-high fence around the landfill
	Restrict general public and large wildlife from onsite hazards	Moderate	Moderate	Moderate	
	Place warning signs in area to warn public of hazards	Low	High	Low	
<ul style="list-style-type: none"> • Water Use Controls <ul style="list-style-type: none"> - Well Permit Regulation - Inspect and Seal Existing Wells 	Restrictions on use of water associated with site				Alternate water sources exist
	Regulate drilling of new wells in potentially contaminated aquifer	Moderate	Moderate	Low	
	Wells in contaminated areas	Low	High	Moderate	Unnecessary Wells will be plugged and abandoned prior to closure under separate action
<ul style="list-style-type: none"> • Public Education 	Increase public awareness of site conditions and remedies through written notices, meetings, and news releases	Moderate	High	Low	The draft IM/IRA DD will be available for public review and comment

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Table 4-2
Evaluation of Remedial Technologies
Containment

Response Action	Description	Effectiveness	Implementability	Cost	Comments
Containment Actions					
• Capping	Provides physical barrier between contaminants and the environment May include surface regrading and revegetation				
– Native Soil Cover	Reduces exposure to, and migration of, contaminated materials through use of a native soil cover	Low	High	Low	Allows some precipitation to infiltrate to the landfill
– Single Barrier Cap	Uses a cap constructed of a single layer of various media, such as clay, flexible membrane liner, asphalt, or concrete-based material	Moderate	Moderate	Moderate	Limits infiltration of precipitation
– Composite Barrier Cap	Uses multiple barrier layer design Media include soil and synthetics	High	Low	High	Minimizes infiltration of precipitation Creates relatively high volume of clean runoff Meets RCRA capping guidance

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Table 4-3
Evaluation of Remedial Technologies
Landfill Gas Collection

Response Action	Description	Effectiveness	Implementability	Cost	Comments
Collection/Removal Actions					
<ul style="list-style-type: none"> • Passive <ul style="list-style-type: none"> - Vents - Venting Trench - Permeable Layer 	Control migration of gases by altering the path of flow using high permeability, preferential pathway	Moderate	High	Low	May be limited by impermeable layers Potential odor Low energy Low O&M
	Pipe vents or gravel columns are used for venting gas at points where it is collecting and building up pressure				Small zone of influence
	Gravel trenches form a path of least resistance for gases	Low	Moderate	Moderate	Depth limited to 20 ft Gases may migrate underneath
	High permeability layer provides preferential pathway for gases	High	Low	High	Most applicable near sources of gases May require cover and drainage layer to prevent freezing
<ul style="list-style-type: none"> • Active <ul style="list-style-type: none"> - Extraction Wells - Extraction Trench - Permeable Layer 	Control gas migration by extraction/collection via vacuum blowers or compressors				May be limited by impermeable layers Not sensitive to freezing or saturation of surface or cover soils
	Gases drawn into a perforated pipe surrounded by permeable material by blower or compressor system	Moderate	High	Low	Good for deep landfills
	Gases drawn into perforated pipe in gravel-filled trench by blower or compressor system	Low	Moderate	Moderate	Depth limited to 20 ft
	Gases drawn into permeable layer by blower or compressor system	High	Low	High	Perched water table or impermeable geological layer limits technology

Table 4-4
Evaluation of Remedial Technologies
Landfill Gas Treatment

Response Action	Description	Effectiveness	Implementability	Cost	Comments
Treatment Actions					
• Thermal	Use of heat to destroy contaminants				
- Open flare	Gases combusted by exposure to open flame	Moderate	High	Low	May require supplementary fuels for a continuous burn Lower combustion efficiency than enclosed flame Open flame may cause public concern
- Enclosed Flare	Gases combusted by exposure to flame within a flame enclosure or stack	High	Moderate	Moderate	For destruction of vapors that are easily burned and have no harmful products of combustion

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5. Development of Alternatives

Technologies passing the evaluation presented in Section 4 are combined into alternatives to address the whole site. Due to use of the presumptive remedy, the number of alternatives is limited and basically consists of various cap cross sections. Institutional controls and the potential for gas treatment in the future are included in all options.

5.1 Cover Design

The proposed action must meet the following requirements for landfill closure [6 CCR 1007-3 Part 265.310]

- 1 Provide long-term minimization of migration of liquids through the closed landfill,
- 2 Function with minimum maintenance,
- 3 Promote drainage and minimize erosion or abrasion of the cover,
- 4 Accommodate settling and subsidence so that the cover's integrity is maintained
- 5 Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoil present

The alternatives consist primarily of different cap cross sections, however a number of design parameters are common to all the capping alternatives. These include the extent of the landfill, wetland and sensitive habitat mitigation, the grading plan, surface water management, and cover components.

5.1.1 Extent of the Landfill

The landfill cap covers the Present Landfill (IHSS 114), the Hazardous Waste Storage Area (IHSS 203) and the asbestos disposal areas. These areas and the extent of the cap are shown on Figure 5-1. The present landfill covers approximately 27 acres. The extent of waste was determined using historical photographs of OU 7 and field tests performed during the Phase I RFI/RI (DOE 1994a).

Although there is no contamination at IHSS 203, it is located within the boundary of the Present Landfill and therefore will be capped along with the landfill mass.

The asbestos disposal areas have an existing soil cover that meets the disposal requirements for asbestos (40 CFR Part 61). However, the asbestos areas also are located within the boundary of the Present Landfill and therefore will be capped.

5 1 2 Wetland and Sensitive Habitat Mitigation

Areas in and around the East Landfill Pond have been designated as wetlands by the U S Army Corps of Engineers as discussed in Section 2 4 In order to provide slope stability along the east face of the landfill, the cover must extend over a portion of the designated wetlands The proposed mitigation plan for onsite wetlands impacted in OUs 4, 5, & 7 is to add acreage to the wetland mitigation site for the Standley Lake Protection Project (SLPP) Approximately eight additional acres is proposed Planting of wetland vegetation for the SLPP is scheduled for the summer

OU 7 has been identified as potential habitat for Preble's meadow jumping mouse which is a candidate for listing as an endangered species As discussed in Section 2 4, under the direction of the U S Fish and Wildlife Service, DOE will attempt to determine the presence of the Preble's Mouse at OU 7 by trapping during the summer of 1995 DOE will mitigate losses to the Preble's habitat due to the remedial action

5 1 3 Grading Plan

Given the extent of the cover, the primary variables in determining the grading plan are the maximum and minimum slopes for the cover The maximum slopes are generally based on stability and erosion concerns The minimum slopes are based on providing adequate surface water drainage for the entire cover area after settlement Settlement estimates determine the minimum cover grades that should be achieved prior to placement of the cover

The existing side slopes of the landfill extending down into the East Landfill Pond are in the range of 3H 1V The slopes on the north side of the East Landfill Pond have exhibited signs of instability in the past including shallow slumping and seeps In order to stabilize these areas, the grading plan includes the placement of fill to buttress the slopes For preliminary planning purposes, it is assumed the slopes are regraded to a 6H 1V slope This is considered to be a stable slope to prevent slumping and erosion

The minimum slope angles are selected based on providing adequate drainage after settlement Conservative settlement estimates are based on a variety of landfill settlement models The resulting grading plans for the top surface has a minimum 7 percent grade Final design analyses may indicate that slightly lower initial grades may be acceptable for OU 7 The settlement analyses are summarized in Appendix F

The grading plan shown in Figures 5-2, 5-2a, and 5-2b shows that the landfill crowns in the center and slopes outward to the surface water diversion ditch The grading plan addresses the 6 CCR 1007-3 Part 265 310 requirements to function with minimum maintenance, promote drainage and minimize erosion or abrasion of the cover, and accommodate settling and subsidence so that the cover's integrity is maintained

5 1 4 Surface Water Management

The OU 7 cover is mounded in the center and graded to drain to the perimeter as shown in Figure 5-2. Along the north, south and west sides of the landfill, the surface water draining off the cover is collected in the existing perimeter surface water drainage ditch and routed to the east around the landfill, the pond embankment. The ditch will be rerouted along the south side of the landfill where the cap extends over the existing ditch. The surface water ultimately discharges into No Name Gulch. Surface water flowing off the landfill to the east flows directly into the East Landfill Pond.

Analyses will be conducted during design to demonstrate compliance with EPA's guidance documents that indicate a maximum allowable erosion rate of 2 tons/acre/year.

5 1 5 Cover Components

Because the landfill received hazardous waste until 1986, a RCRA Subtitle C cover or equivalent is required. There are five types of layers that are typically used in a RCRA cover: vegetative cover, lateral drainage, barrier, gas collection and grading fill. The purpose of each layer and the materials that may be used are discussed in the following sections.

5 1 5 1 *Vegetative Cover Layer*

The vegetative cover layer is intended to provide a suitable growth media for local vegetation to become established after construction of the cover. The vegetative cover soil must provide suitable moisture retention characteristics to establish vegetation. A secondary intent of this vegetative soil cover is to provide an insulation layer over the barrier layers to prevent freezing. This design criterion dictates the ultimate depth of the vegetative cover soil.

A three-foot vegetative soil layer is included in all cover options. The vegetative layer is made up of 2.5 feet of soil under 0.5 feet of topsoil. The main plant species proposed for revegetation consist of tall-prairie grasses, western wheatgrass, blue gramma, green needlegrass, and little bluestem (SCS 1993).

5 1 5 2 *Lateral Drainage Layer*

This layer is intended to intercept and drain any water that infiltrates through the vegetative cover. The lateral drainage layer is continuous over the top of the cover and discharges collected water at the perimeter of the cover.

Materials considered for the lateral drainage layer include the following: granular soil, geotextiles, geonets, and geocomposites.

Each is described in more detail below

Granular Soil

Granular drainage layers have been used successfully for many years in a variety of drainage layer applications. Media may consist of coarse sands or fine gravels. The use of granular drainage layers in a cover section requires the use of a geotextile filter fabric between the vegetative cover soil and the drainage soil to prevent migration of fines. In addition, placed over a geomembrane, the material must be reasonably well graded and not too coarse grained in order to prevent damage to the geomembrane.

For these reasons, soil drainage layers in cover applications have been replaced or supplemented with geosynthetic drainage layers which have higher permeability and do not damage underlying geosynthetics.

Geotextiles

Geotextiles are commonly used as filter layers between soils materials with differing grain size distributions (i.e., between drainage layers and infiltration layers and/or barrier layers). The geotextile acts to retain fines and prevent them from migrating into drainage layers. The migration of fines can result in a reduction in permeability. Geotextile filters are designed based on the Apparent Opening Size (AOS) of the geotextile and the grain size of the soil to be retained.

Geotextiles are also used as cushion layers between geomembranes and coarse grained soils that could cause damage. In this application, the thickness and mass/unit area of the geotextile is the critical design factor. In some cases, very thick and very high permeability geotextiles have been used for lateral drainage layers. However, they are generally used in conjunction with geonet drainage products.

Geonets

Geonets have become the most common type of lateral drainage layers used in landfill cover designs. The benefits of geonets for this type of application are listed below.

- High permeability
- No damage potential for geomembranes
- Competitive cost compared to granular drainage layers
- Ease of installation
- Compatibility with a wide range of leachates

Geocomposites

Geocomposites are a combination of geonet and geotextile. The geotextile is generally heat bonded to one or both sides of the geonet. A geocomposite provides the high permeability benefits of a geonet and the filtration characteristics of a geotextile while being installed in one step.

A geocomposite is used for the drainage layer in the cover options.

5.1.5.3 Barrier Layers

Barrier layers are included in the cover design to prevent water from infiltrating into the waste and to prevent uncontrolled venting of gases at the surface. The three types of barrier layers considered for the OU 7 cover can be used alone or in combination. These include flexible membrane covers (FMC), geosynthetic clay liners (GCL), and compacted clay covers.

FMC

Geosynthetic FMC materials are available in a wide variety of compositions, thicknesses, surface textures, colors, and other physical properties. FMC material laminated with geonets and geotextiles that serve dual functions as barrier and drainage layers are also available.

The FMCs with permeability of approximately 10-13 cm/sec considered for the OU 7 cover include High Density Polyethylene (HDPE) and Polyvinyl Chloride (PVC). Each has advantages and disadvantages in terms of durability, chemical compatibility, strength, elasticity and ease of installation. The selection of the type of FMC material is made during the final design.

GCL

A GCL is composed of a commercial bentonite layer that is sandwiched between a woven and non-woven geotextile. The bentonite in a GCL is supplied at a relative low moisture content and can swell to many times its installed thickness if it is exposed to migrating water. The bentonite has a very low inherent permeability, approximately 10⁻⁹ cm/sec. Since the material is supplied at a low initial moisture content, it is not susceptible to desiccation and cracking. Research on GCLs has indicated that they will exhibit low permeability even after wetting and drying cycles and/or freezing cycles.

Compacted Clay

Compacted clay covers consist of any natural soil deposit that can be placed and compacted to achieve a permeability of 10⁻⁷ cm/sec or less. These generally consist of fine grain soils that exhibit the characteristic of plasticity. Coarse grained soils can be

mixed with various percentages of bentonite to achieve the required permeability and plasticity characteristics

Compacted clay covers are generally placed at moisture contents above optimum and therefore are susceptible to desiccation, cracking, and freeze cracking. After initial cracks are formed, the cracks do not heal like GCLs unless they are placed under very high normal loads. This will not be the case for this application. However, because they are placed in relatively thick layers (2 feet), they can accommodate settlement and some surface cracking or deterioration without complete failure.

The cover alternatives have various combinations of these materials for the barrier layer.

5.1.5.4 Gas Collection Layer

The gas collection layer is intended to collect migrating gases across the entire landfill surface and transmit them to selected discharge points. The gas collection layer is placed directly over the waste/daily cover material to collect the migrating gases. Gas discharging from the landfill collected in this layer flows to vent pipes and/or gravel columns where it can vent through the cover.

A geocomposite is used for the gas collection layer in all alternatives. As discussed under lateral drainage, a geocomposite is a geonet drainage layer with geotextile bonded to both sides to prevent infiltration of fine soils.

All cover options incorporate monitoring the gas composition, concentration and flow rate during post-closure until treatment requirements can be determined. The design incorporates provisions to facilitate gas treatment in the event it is determined to be necessary.

5.1.5.5 General Grading Fill

In order to achieve surface water drainage off the landfill, general grading fill is required. The intent of the grading fill is to achieve a crown in the center of the landfill to shed water off the slopes. The fill is thickest in the center of the landfill and thins towards the edges. The fill is placed directly over the gas collection layer.

The general fill material can consist of almost any natural soil material. There are no specific restrictions on the composition of the soil as long as it can be compacted to a firm unyielding subgrade. The material is expected to come from both onsite and offsite sources.

5.2 Description of Alternatives

Alternatives are developed to cover the range of remedial actions available under the presumptive remedy. The capping options may include the following elements as described in Section 5.1:

- institutional controls
- three-foot vegetative soil layer
- geocomposite lateral drainage layer
- various combinations of barrier layers
- geonet gas collection layer and venting system
- grading fill

The primary variable is the barrier layer in the cover.

5.2.1 Alternative 1: No Action

Under Alternative 1, no action is taken. The No Action alternative required under the NCP provides a baseline for comparison of other alternatives. Under the existing conditions, the landfill has a permeability of approximately 1×10^{-2} cm/sec. This alternative is shown in Figure 5-3.

5.2.2 Alternative 2: Institutional Controls

Alternative 2 includes institutional controls for both the landfill and groundwater.

5.2.2.1 Land Use and Access Restrictions

A chain link fence and warning signs limit access to the landfill. In addition, RFETS is fenced with limited access and a 24-hour security force.

As part of the closure of the landfill, DOE will record a notation on the property deed to identify it as a hazardous waste landfill and restrict future use. DOE may lease RFETS property for up to ten years, but because Rocky Flats is listed on the National Priorities List for CERCLA, DOE must obtain EPA approval. EPA determines if the terms and conditions of the lease agreement are consistent with safety and the protection of public health and the environment (DOE 1994c).

In addition, under the Community Environmental Response Facilitation Act (CERFA), an amendment to CERCLA, DOE is required to notify the state of any lease that will encumber property on which any hazardous substance was stored for one year or more, and on which they plan to terminate federal government operations (DOE 1993c).

5 2 2 2 Groundwater Controls

Under this alternative, the existing restrictions on use of groundwater at the site are maintained. There are no existing water supply wells at RFETS. The nearest supply wells downgradient of the landfill are two miles from OU 7. Institutional controls include monitoring of one upgradient and three downgradient wells as described in the post closure plan in 8 2.

The drilling of new wells is regulated by RFETS and by the State of Colorado. EG&G Rocky Flats Standard Operating Procedure No. GT 6, Revision 2 requires that a Well Installation Notification (WIN), Form GT 6A, be completed to insure that new well administrative controls are met by the inclusion of requester information, installation methods, purpose, initial well permit data, environmental protection measures, and additional information. The requester must also supply information necessary to prepare and file applicable well permits required by the State of Colorado.

5 2 2 3 EPA Reviews

As required by CERCLA, Section 121(c) and NCP Section 300.430 (f) (4) (ii), Statutory Reviews are necessary for "any site at which a post-SARA remedy, upon attainment of the ROD cleanup levels, will not allow unlimited use and unrestricted exposure." Reviews must occur at least every 5 years but may be terminated when hazardous substances, contaminants, and pollutant levels allow for unlimited use and unrestricted exposure.

The reviews assure that the response action remains protective of the public health and environment, i.e. effectiveness of the landfill cap and adequacy of land-use restrictions or controls. In most cases, a Level I review is adequate. For Level I reviews, a site visit, limited analysis of site conditions and the information gathered during routine operation and maintenance activities will probably suffice. In the event of new or revised regulations or changes in the site conditions, the level of review may be adjusted.

Under existing conditions, the landfill has a permeability of approximately 1×10^{-2} cm/sec. The cover cross section for this alternative is the same as that for No Action and is shown in Figure 5-4.

5 2 3 Alternative 3 Native Soil Cover

Alternative 3 consists of a 36-inch native soil cover placed directly over the grading fill. The cap cross section is shown in Figure 5-4. Institutional controls are included as described in Section 5 2 2.

The Native Soil Cover has a permeability of approximately 1×10^{-2} cm/sec

5 2 4 Alternative 4 Single-Barrier Clay Cover

Alternative 4 consists of a single-barrier clay cover and institutional controls. The cover consists of the following layers:

- three-foot vegetative soil layer
- geocomposite lateral drainage layer
- 24-inch compacted clay
- geonet gas collection layer and venting system
- grading fill

This is shown in Figure 5-4. The barrier layer is made up of a clay liner with a permeability of approximately 1×10^{-7} cm/sec. The gas collection system has provisions for gas treatment if determined necessary during the post-closure monitoring.

5 2 5 Alternative 5 Single-Barrier FMC Cover

Alternative 5 consists of a single-barrier FMC cover and institutional controls. The cover consists of the following layers:

- three-foot vegetative soil layer
- geocomposite lateral drainage layer
- FMC
- bedding layer
- geonet gas collection layer and venting system
- grading fill

The FMC barrier layer has a permeability of approximately 1×10^{-13} cm/sec. It is placed on 12-inches of soil to cushion the FMC from the underlying geonet. The soil has a permeability of approximately 1×10^{-2} cm/sec and is not designed to act as a barrier. This cover is shown in Figure 5-4. The gas collection system has provisions for gas treatment if determined necessary during the post-closure monitoring.

5 2 6 Alternative 6 Single-Barrier GCL Cover

Alternative 6 consists of a single-barrier GCL cover and institutional controls. The cover consists of the following layers:

- three-foot vegetative soil layer
- geocomposite lateral drainage layer
- GCL

- geonet gas collection layer and venting system
- grading fill

The barrier layer is a GCL with a permeability of approximately 3×10^{-9} cm/sec. This cover section is shown in Figure 5-4. Gas treatment will be added if determined necessary during the post-closure monitoring.

5.2.7 Alternative 7 Single-Barrier FMC with a Low Permeability Soil Cover

Alternative 7 consists of institutional controls and a cover with an FMC barrier and a 12-inch layer of low permeability soil. The cover consists of the following layers:

- three foot vegetative soil layer
- geocomposite lateral drainage layer
- FMC
- 12-inches of low permeability soil
- geonet gas collection layer and venting system
- grading fill

The presence of the low permeability soil (approximately 1×10^{-5} cm/sec) gives the cover system some of the benefits of a composite cover, without the rigorous installation requirements of a full clay liner. The barrier layer is an FMC with a permeability of approximately 1×10^{-13} cm/sec. This cover is shown in Figure 5-4. The gas collection system is designed to facilitate gas treatment if determined necessary during the post-closure monitoring.

5.2.8 Alternative 8 Composite-Barrier FMC and GCL Cover

Alternative 8 is a true composite barrier with both FMC and GCL. Also included in this alternative are institutional controls. The cover consists of the following layers:

- three-foot vegetative soil layer
- geocomposite lateral drainage layer
- FMC
- GCL
- geonet gas collection layer and venting system
- grading fill

The barrier layers are an FMC with a permeability of approximately 10^{-13} cm/sec and a GCL with a permeability of 3×10^{-9} cm/sec. This cover is shown in Figure 5-4. The gas collection system has provisions for gas treatment if determined necessary during the post-closure monitoring.

5.2.9 Alternative 9 Composite-Barrier FMC and Clay Cover

Alternative 9 is a composite barrier with both FMC and compacted clay as well as institutional controls. The cover consists of the following layers:

- three-foot vegetative soil layer
- geocomposite lateral drainage layer
- FMC
- 24-inches of compacted clay
- geonet gas collection layer and venting system
- grading fill

This cover design follows EPA guidance documents for a RCRA Subtitle C facility (EPA 1989d). The FMC has a permeability of approximately 10^{-13} cm/sec and is overlying a compacted clay liner with permeability less than or equal to 10^{-7} cm/sec has a permeability of approximately 10^{-13} cm/sec. This cover is shown in Figure 5-4. The gas collection system has provisions for gas treatment if determined necessary during the post-closure monitoring.

5.3 Screening of Alternatives

The purpose of this screening is to limit the number of alternatives to be considered in the detailed analysis. The nine alternatives are evaluated in terms of effectiveness, implementability and cost.

5.3.1 Screening Criteria

5.3.1.1 Effectiveness

The effectiveness criteria include the degree to which a technology meets RAOs and ARARs, reduces toxicity, mobility or volume through treatment, affords long-term protection, and minimizes short-term impacts. Alternatives that are not protective of human health and the environment are eliminated from further consideration.

As discussed in Section 3.5, RAOs for OU 7 include the following:

- prevent direct contact with landfill contents
- minimize infiltration and resulting contaminant leaching to groundwater
- control surface water runoff and erosion
- control landfill gas (and treat if necessary)

The regulations require that the cover meet the requirements 6 CCR 1007-3 Part 265.310. The most important requirement for this evaluation is that the cover must

have a permeability less than the underlying bedrock. As discussed in Section 2.3, the weathered bedrock has a permeability of 10^{-6} to 10^{-7} cm/sec.

Each of the alternatives are evaluated using the Hydrologic Evaluation of Landfill Performance (HELP) (EPA 1994c) model to determine performance. A discussion of the HELP model and the inputs used for this evaluation as well as output runs are in Appendix G.

5.3.1.2 Implementability

The implementability evaluation criteria includes a determination of the technical and administrative feasibility of implementing the technology. Alternatives that are not technically or administratively feasible or that require equipment or specialists that are unavailable in the IM/IRA time frame are eliminated from further consideration.

Technical issues relating to implementation include availability of materials to construct the cover, ease of construction, and post construction repairs. Availability of general fill geosynthetics and vegetative layer materials are equivalent among the alternatives, whereas, availability of barrier soil and barrier soil preparation requirements differ. Ease of construction considers equipment, labor, and construction quality assurance (CQA) efforts required for subgrade preparation and cover installation. Post-construction repair considers equipment, labor and CQA effort required to repair a small area of cover.

Administrative feasibility addresses the ability to obtain approvals from regulatory agencies and coordination with other agencies.

5.3.1.3 Cost

A preliminary cost estimate was developed for each alternative. These costs are conceptual and should be used for comparison only. The estimates include direct and indirect capital and O&M costs. The present worth cost is based on a discount rate of 3 percent over the 30 year post-closure period. It was assumed that O&M costs are the same for all capping options. The cost estimates and assumptions are provided in Appendix H.

5.3.2 Alternative 1: No Action

5.3.2.1 Effectiveness

The No Action alternative does not meet any of the RAOs, nor does it address the closure requirements. The HELP model shows an average annual leakage rate of 1.4 inches/year. Figure 5-1 compares this leakage rate with all the other alternatives.

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There is no reduction in toxicity, mobility or volume through treatment although there may be some decrease due to natural attenuation. There are no short-term impacts. There is no monitoring, allowing long term threats to human health and the environment to go undetected.

5.3.2.2 *Implementability*

The No Action Alternative involves no implementation but, because it does not address RAOs or closure requirements, it is unlikely to receive approvals from CDPHE or EPA.

5.3.2.3 *Cost*

The conceptual cost estimate for Alternative 1, No Action, is

Total capital cost	\$0
Annualized Annual/Periodic O&M cost	\$0
Total present worth	\$0

Cost estimates and associated assumptions are in Appendix H.

5.3.3 *Alternative 2 Institutional Controls*

5.3.3.1 *Effectiveness*

Direct contact with the landfill contents can be limited by access and use restrictions if properly enforced. However, the exposure pathway is not eliminated. No attempt is made under this alternative to address infiltration and leaching, surface water runoff and erosion, or landfill gas. The leakage rate for this alternative is the same as that for No Action. However, groundwater monitoring would detect changes in contamination or migration.

Closure regulations are not met for this alternative. The final interim cover has a permeability of approximately 1×10^{-2} cm/sec which is not less than that of the underlying bedrock.

As with the No Action alternative, toxicity, mobility or volume of contaminants may decrease due to natural attenuation. Apart from installing the fence, there is limited construction under this alternative so short term impacts are minimal.

5.3.3.2 *Implementability*

Construction is minimal, groundwater monitoring procedures are standard and administrative requirements are straightforward. This alternative involves limited

implementation, but it is unlikely to receive approvals from CDPHE or EPA because it does not address RAOs or closure requirements

5 3 3 3 *Cost*

The conceptual cost estimate for Alternative 2, Institutional Controls, is

Total capital cost	\$134,900
Annualized Annual/Periodic O&M cost	\$38,500
Total present worth	\$889,100

Cost estimates and associated assumptions are in Appendix H

5 3 4 *Alternative 3 Native Soil Cover*

5 3 4 1 *Effectiveness*

The Native Soil Cover provides a physical barrier to minimize the potential for human contact with the landfill contents. Depending on the permeability characteristics of the native soil, this cover may reduce infiltration into the groundwater. The HELP model shows an average annual leakage rate of 1.1 inches/year. The leakage rate for this cover is slightly less than no action. Although this alternative does not reduce toxicity, mobility, or volume through treatment, at this leakage rate, it will reduce leachate production over time. The cover is designed to control surface water runoff and erosion. This alternative does not address landfill gas.

The permeability of the native soil cover is approximately 1×10^{-2} cm/sec. This does not meet the requirement under 6 CCR 1007-3 Part 265.310 that the cover must have a permeability less than the underlying bedrock (10^{-6} to 10^{-7} cm/sec).

With proper maintenance, the cover has a design life of 30 years and therefore affords long-term protection. Institutional controls to address access and use should be effective in preventing a breach of the cap. The construction of the cover may have some short-term impacts due to dust generation and erosion during construction. However, these are easily mitigated using standard construction techniques.

5 3 4 2 *Implementability*

The native soil cover can consist of any mineral soil and can be obtained from either onsite or offsite sources. Placement of the native soil cover is limited to placing and spreading the material in a single lift directly over the existing intermediate soil cover. The material is end dumped from haul trucks and spread with a dozer to the desired

depth The surface is graded to design lines and grades with motor graders and then revegetated

Implementation is straightforward Materials should be easily obtained, construction methods are standard and CQA is minimal Administratively, it is unlikely to receive regulatory approvals because it does not meet closure requirements

Post-construction repairs involving replacement of soil or vegetation would be relatively simple

5 3 4 3 Cost

The conceptual cost estimate for Alternative 3, Native Soil Cover, is

Total cost	\$6,571,100
Annualized Annual/Periodic O&M cost	\$47,600
Total present worth	\$7,503,700

Cost estimates and associated assumptions are in Appendix H

5 3 5 Alternative 4 Single-Barrier Clay Cover

5 3 5 1 Effectiveness

The Single Barrier Clay Cover Alternative meets all the RAOs The cover, in conjunction with institutional controls, prevents direct contact with landfill contents and minimizes infiltration and leaching to groundwater The cover is designed to control surface water runoff, erosion and landfill gas migration

The clay barrier layer has a permeability of approximately 10^{-7} cm/sec which is equal to the underlying bedrock and therefore meets the closure requirement

This alternative does not reduce toxicity, mobility or volume through treatment, however the cover reduces the average annual leakage rate to 1 inch which will decrease leachate production over time

The cover has a design life of 30 years and therefore affords long-term protection Institutional controls to address access and use should be effective in preventing a breach of the cap However, because there is no FMC or vapor barrier above the clay, there is potential for dessication The construction of the cover may have some short-term impacts due to dust generation and erosion during construction, however, these are readily mitigated using standard construction techniques

5 3 5 2 *Implementability*

Implementation of this cover option requires that a borrow source of fine grained soil meeting the design specifications. At this time, there are no known borrow sources at RFETS that could be used for a clay cover material. Therefore, it is expected that an offsite borrow source will be required. Alternatively, the onsite alluvium could be used if it is screened and mixed with bentonite.

Once a source of material is located, the material is hauled to the site for processing and conditioning. The processing consists of reducing the maximum particle size to one inch or less and moisture conditioning to the specified moisture content range. This generally requires the use of a mixing table where the material is spread in thin lifts (6 to 12 inches) to allow processing and conditioning. Particle size reduction is achieved with discs and/or soil mixers. Water is generally added during the processing to facilitate particle size reduction and to increase the moisture content to the desired range.

Once the material meets particle size and moisture content requirements, it is hauled to the landfill and placed in controlled lifts. Each lift is compacted and tested. Prior to placing a new lift of clay, the underlying lift is scarified to facilitate bonding between lifts. This process is repeated until the desired thickness of clay cover is obtained. The surface of the completed clay cover is then graded to the design lines and grades. Then, the vegetative soil cover is placed over the clay cover.

Equipment for preparation of the clay usually includes bulldozers, water pulls, pavement recyclers or soil mixers, and large diameter earth turning discs used in the farming industry. Additional CQA monitoring of the clay preparation is also required to ensure that the clay material will meet specifications when it is placed. The clay preparation process is sensitive to frost and heavy rains and special steps must be taken to control rainwater run on to the prepared clay stockpiles.

Clay test fills are usually constructed using the proposed clay materials and construction equipment. Large scale infiltrometer tests are then conducted to confirm permeability of the clay material and construction techniques.

Two geocomposite layers, one for lateral drainage and one for gas collection, are also required. These materials are readily available and relatively straightforward to install. Geotextiles are unrolled and seams are either overlapped, heat bonded, or sewn together. CQA involves material conformance testing and observation of the deployment and seaming operations to document conformance with the plans and specifications.

Because compacted clay covers are placed wet of optimum to achieve the minimum permeability. There is an increased potential for desiccation. In this cover section, there is no FMC or other vapor barrier above the compacted clay cover. Therefore, it is expected that over time the clay will dry and crack (Corser et al., 1991). Without substantial confining pressure, compacted clay covers that desiccate and crack will not re-heal even if they are subjected to free moisture.

A stockpile of clay can be maintained on site to ensure a source of suitable clay is available should repairs become necessary. Otherwise GCLs or other appropriate materials can be warehoused for the same purpose. CQA testing of the clay material used for repair is the same as during construction so mobilization of those resources is required. If the area is large enough, special designs of clay layer tie-ins to existing clay may be necessary.

This alternative, the Single Barrier Clay Cover, meets RAOs and closure requirements and therefore should be administratively feasible.

5.3.5.3 Cost

The conceptual cost estimate for Alternative 4, Single-Barrier Clay, is

Total capital cost	\$10,747,600
Annualized Annual/Periodic O&M cost	\$47,600
Total present worth	\$11,680,200

Cost estimates and associated assumptions are in Appendix H.

5.3.6 Alternative 5 Single-Barrier FMC

5.3.6.1 Effectiveness

The Single Barrier FMC Cover Alternative meets all the RAOs. Institutional controls will prevent access and use of the area which may result in breaching of the cap. The cover will prevent direct contact with landfill contents and minimize infiltration and leaching of contaminants to groundwater. The cover is designed to control surface water runoff, erosion, and landfill gas migration.

The FMC barrier layer has a permeability of approximately 1×10^{-13} cm/sec which is less than the underlying bedrock and therefore meets the closure cover requirement.

This alternative does not reduce toxicity, mobility or volume through treatment, however the cover reduces the average annual leakage rate to 0.021 inches which will decrease leachate production. The 30 year design life provides long-term protection.

Short-term impacts during construction include dust generation and erosion and are easily mitigated

5.3.6.2 Implementability

Although specialized, a number of sources exist for the purchase and installation of FMC. Thickness, composition, and type of FMC will be determined during design. The geocomposite layers used for drainage and gas collection are also readily available and relatively easy to install as discussed under Alternative 4.

Good quality control and quality assurance during fabrication, placement, and seaming of the FMC is essential. Prior to the material arriving at the site, quality control certifications from the manufacturer are reviewed to confirm that the material meets the specifications. After the material arrives onsite, quality assurance samples are obtained to confirm compliance. Specifications for the material delivered to the site are met.

The 6-inch bedding layer must be prepared to meet certain grading, moisture content, and density requirements. Once the FMC is laid out, panels are seamed together using fusion and/or extrusion methods. A hot wedge or chemical is used to melt the panel surfaces in fusion seaming. The panels then bond directly to each other. In extrusion welding, molten polymer is extruded over the edge or between the panels, melting the surface of the sheets. The panels and polymer then cool and bond together.

All seaming methods require extensive CQA. Destructive and non-destructive testing is generally performed. In destructive tests, a piece of the seam is cut out and removed for onsite or laboratory testing. The sample undergoes shear and peel testing to give an indication of the overall quality of the seaming. Non-destructive testing attempts to validate the integrity of all of the seams. Common methods include the air lance, pressurized dual seam, and vacuum chamber box. Each method is applicable to certain seam configurations and types of FMC.

To repair an FMC, special welding equipment and qualified labor to install FMC patches would have to be mobilized. The FMC welding processes are sensitive to the presence of dust or moisture on the sheet, as well as the ambient sheet temperature. CQA must generally be performed during the daylight to enable an adequate visual inspection of the material, and both nondestructive and destructive seam testing are required. Weather and work schedule thus can greatly influence the cost and quality of an FMC repair.

Depending on the location of the repair, geotextile seaming personnel may be required. Otherwise, simply overlapping or heat bonding the material may be sufficient. In either case, CQA personnel need to observe and document the repair work.

The Single-Barrier FMC Cover Alternative meets RAOs and closure requirements and therefore should be administratively feasible

5 3 6 3 *Cost*

The conceptual cost estimate for Alternative 5, Single-Barrier FMC, is

Total capital cost	\$8,781,200
Annualized Annual/Periodic O&M cost	\$47,600
Total present worth cost	\$9,713,800

Cost estimates and associated assumptions are in Appendix H

5 3 7 *Alternative 6 Single Barrier-GCL*

5 3 7 1 *Effectiveness*

The Single Barrier GCL Cover Alternative meets all the RAOs. The GCL barrier layer has a permeability of 3×10^{-9} cm/sec which is less than the underlying bedrock and therefore meets the closure cover requirement.

This alternative does not reduce toxicity, mobility or volume through treatment, however the cover decreases leachate production by reducing the average annual leakage rate to 0.035 inches. The cover is designed to last 30 years, however, GCLs have only been in use for about seven years and the long-term protectiveness of this technology is not proven. Short-term impacts during construction include dust generation and erosion which can be mitigated using standard construction techniques.

5 3 7 2 *Implementability*

GCL materials are generally available as composites of geotextile or HPDE and various forms of bentonite. Geosynthetic drainage and gas collection materials are available as single layers of geotextile or laminated combinations of geotextile and geonet. No soil material, other than the vegetative layer, are required in this alternative.

In this alternative, a gas collection layer is placed directly above the waste followed by placement of overlying GLC, lateral drainage, and vegetative layers. Although the gas collection layer also serves as a cushion layer for the GCL, it is necessary to prepare the general fill for geosynthetic placement. This surface is graded and rolled until it is smooth and firm without any protrusions or depressions.

Due to the large absorptive capacity of GCLs, they must be stored to prevent exposure to snow or rain. This generally requires that the material be stored in a covered

container or enclosed building unit deployment. Placement of the GCL as part of the cover construction is relatively simple. The rolls are unrolled over the surface of the landfill with an overlap of 6 to 12 inches. Vegetative cover soil is then placed directly over the GCL. The construction process must be sequenced to allow all of the GCL that is deployed in one day to be covered with vegetative soil by the end of the day to ensure that the exposed GCL is not damaged by precipitation.

CQA observation and testing associated with the placement of a GCL is limited to review of quality control testing, conformance testing of the material delivered to the site, and observation of the deployment to confirm overlaps.

Post-construction repairs to GCL can be accomplished by removing the vegetative soil cover and overlapping a section of new GCL over the damaged area. No seaming is required with a GCL. The vegetative soil cover is then replaced. Very minor defects in the GCL may be healed by the swelling characteristics of the GCL when exposed to any free liquids without specific repair measures.

The Single-Barrier GCL Cover Alternative meets RAOs and closure requirements and therefore is considered administratively feasible.

5.3.7.3 Cost

The conceptual cost estimate for Alternative 6, Single-Barrier GCL, is

Total capital cost	\$9,199,300
Annualized Annual/Periodic O&M cost	\$47,600
Total present worth cost	\$10,131,900

Cost estimates and associated assumptions are in Appendix H.

5.3.8 Alternative 7 Single-Barrier FMC with a Low Permeability Soil Cover

5.3.8.1 Effectiveness

The Single Barrier FMC with a Low Permeability Soil Cover Alternative meets all the RAOs. The FMC barrier layer has a permeability of approximately 10^{-13} cm/sec which is less than the underlying bedrock and therefore meets the closure cover requirements.

This alternative does not reduce toxicity, mobility or volume through treatment, however, the cover reduces the average annual leakage rate to 0.00016 inches, decreasing leachate production. This leakage rate is substantially less than any of the previous cover alternatives. The reduction in leakage is primarily the result of the presence of the low permeability soil below the FMC. The low permeability soil serves

two functions the first is to provide a good bedding layer for the FMC and the second is to reduce the ability of a small leak in the geomembrane to spread out over a large area and infiltrate into the waste

The 30-year design life with institution controls to protect the cover assure long-term protection Short-term impacts during construction, including dust generation and erosion, are readily mitigated

5 3 8 2 *Implementability*

Geosynthetic FMC materials are available in a wide variety of compositions, thicknesses, surface textures, colors, and other physical properties FMC material laminated with geonets and geotextiles that serve dual functions as barrier and drainage layers are also available The type and weight of the FMC will be determined during design

The low permeability soil required in this alternative should be available from onsite borrow sources Some screening to remove oversize particles or admixture of clay material may be required to meet the gradation and permeability requirements of 1×10^{-5} cm/sec These requirements are significantly less than the clay barrier layer in Alternative 9 which needs to meet a much more rigid specification for gradation, moisture content, and compaction in order to achieve its required 1×10^{-7} cm/sec permeability

The vegetative soil, drainage and gas collection layers are all readily available

Alternative 7 calls for a geonet gas collection layer to be placed above the waste followed by, from bottom up, the low permeability soil, FMC, drainage layer, and vegetative layer The gas collection layer could also be placed on top of the low permeability soil instead of the directly on the waste surface, provided that the soil can readily transmit gas from the waste mass This eliminates the need to prepare the waste surface for geosynthetic deployment This option will be evaluated during final design

Placement of geosynthetic materials for gas collection and drainage employ standard construction equipment, labor and CQA techniques as discussed in Alternative 4 Placement of the low permeability soil can be accomplished with a truck/loader equipment fleet or scraper equipment fleet The equipment sizes and number depend on the haul distance, the haul volume, and the required completion schedule

Material gradation, moisture content, and compaction are monitored during material placement operations The surface of the low permeability soil must be prepared as a bedding for the FMC Standard construction equipment, labor, and CQA techniques can be used

FMC is unrolled or slid into position over the low permeability soil. The seams are either fusion bonded or welded by an extrusion process. A great deal of CQA effort is expended to perform not only material conformance tests before installation but also seam inspection, leak detection, and seam strength testing during and after installation. Installation and post construction repair work of the FMC are discussed in detail under Alternative 5.

The Single-Barrier FMC and Low Permeability Soil Cover Alternative meets RAOs and closure requirements and provides two layers of protection. Therefore, it is considered administratively feasible.

5.3.8.3 Cost

The conceptual cost estimate for Alternative 7, Single Barrier FMC Cover with a Low Permeability Soil Cover, is

Total capital cost	\$9,400,500
Annualized Annual/Periodic O&M cost	\$47,600
Total present worth	\$10,333,100

Cost estimates and associated assumptions are in Appendix H.

5.3.9 Alternative 8 Composite-Barrier FMC and GCL

5.3.9.1 Effectiveness

The Composite-Barrier FMC and GCL Cover Alternative meets all the RAOs. The FMC barrier layer has a permeability of approximately 10^{-13} cm/sec and the GCL has a permeability of approximately 10^{-9} cm/sec. Both are less than the permeability of the underlying bedrock and therefore meet the closure requirement.

This alternative does not reduce toxicity, mobility, or volume through treatment, however, the cover reduces the average annual leakage rate to 0.00000002 inches, thus decreasing leachate production due to infiltration. Limited long-term experience with GCLs results in uncertainty regarding the long-term effectiveness of this technology. Potential short-term impacts during construction include dust generation and erosion.

5.3.9.2 Implementability

As mentioned earlier, various combinations of geosynthetic materials can be readily obtained as composites or laminants. The 36-inch vegetative layer is the same as the other alternatives. No other soil or clay is called for in this alternative, so soil availability is not a factor.

This cover system could be constructed in two separate layers, a GCL and an FMC. The implementability criteria would be similar to those described for Alternative 5 (single FMC cover) and Alternative 6 (single GCL). Alternatively, some manufacturers are producing a single material that consists of GCL bonded to an FMC. This material can be deployed in one step. As a minimum the seams are overlapped. However, this system has the potential for FMC components to be welded to each other in a fashion similar to Alternative 5.

Post construction repairs to this cover system would be made to each component individually as described in Alternatives 5 and 6. As a minimum, repairs to the combined materials would consist of the placing a bonded GCL/FMC over the damaged area with sufficient overlap around the damaged area. To further secure the patch, a single layer of FMC could be placed over the patch and welded to the surrounding FMC.

The Composite Barrier FMC and GCL Cover Alternative fulfills RAOs and closure requirements and provides two barrier layers. Thus, it is considered an administratively feasible alternative.

5.3.9.3 Cost

The conceptual cost estimate for Alternative 8, Composite-Barrier FMC and GCL Cover, is

Total capital cost	\$9,663,600
Annualized Annual Periodic O&M cost	\$47,600
 Total present worth	 \$10,596,200

Cost estimates and associated assumptions are in Appendix H.

5.3.10 Alternative 9 Composite-Barrier FMC and Clay Cover

5.3.10.1 Effectiveness

The Composite-Barrier FMC and Clay Cover Alternative meets all the RAOs. It also follows EPA's guidance on the recommended cover cross section for a RCRA Subtitle C cap. The FMC barrier layer has a permeability of approximately 10^{-13} cm/sec and the compacted clay has a permeability of approximately 10^{-7} cm/sec. Both are less than or equal to the permeability of the underlying bedrock and therefore meet the closure requirements.

This alternative does not reduce toxicity, mobility or volume through treatment, however the cover reduces the average annual leakage rate to 0.00001 inches thus

decreasing leachate production The 30 year design life with institution controls to preserve the cover assures protection over the long-term Potential short-term impacts during construction include dust generation and erosion

5.3.10.2 Implementability

The geotextile and FMC materials are readily available The clay material used for the barrier layer may have to be developed by modifying a local borrow source material or importing it from offsite A recently constructed landfill at RFETS used a shale material purchased from a local aggregate company as a low permeability barrier in the landfill liner system Screening local borrow source material and adding bentonite admixture is also a possible source for low permeability clay

As discussed under Alternative 4, conditioning and placement of the clay layer is important in achieving the required permeabilities layer Over-moisturizing the material can lead to desiccation, under-moisturizing can lead to lower permeability due to inadequate compaction resulting in lamination of placement layers Inclusion of the FMC over the clay material tends to inhibit desiccation provided that intimate contact between the clay and the FMC is maintained by the vegetative cover surcharge

Installation of the FMC is discussed in detail in Alternative 5

Equipment, labor, and CQA requirements for installation of geosynthetics in this option are similar to those previously discussed for Alternatives 4 and 5

Post construction repairs are complicated by having two barrier layers Repair of the clay layer is discussed in Alternative 4 and the repair of FMC is discussed in Alternative 5

The Composite Barrier FMC and Clay Cover Alternative meets RAOs and closure requirements in addition to following EPA guidance on the recommended cover cross section Thus, it is considered likely to receive approvals from CDPHE and EPA

5.3.10.3 Cost

The conceptual cost estimate for Alternative 9, Composite-Barrier FMC and Clay Cover, is

Total capital cost	\$11,181,100
Annualized Annual/Periodic O&M cost	\$47,600
Total present worth	\$12,113,700

Cost estimates and associated assumptions are in Appendix H

5.3.10.4 Summary of Screening

The screening of alternatives is based on effectiveness, implementability, and cost as described in Section 5.3.

Table 5-1 summarizes the permeability and leakage rates for each of the alternatives. These parameters, in addition to long-term permanence, are used to compare the effectiveness of each alternative. Figure 5-4 shows the comparison of the leakage rates graphically.

A summary of the comparative analysis of the alternatives is in Table 5-2.

Institutional Controls, Native Soil Cover and the Single Barrier Clay Cap are eliminated because they ranked low on effectiveness as demonstrated by the low permeabilities and/or high leakage rates.

Although GCLs have good permeability and low leakage rates, they have been in use for less than 10 years so long term effectiveness is in question. Because the panels are not seamed, settlement or movement in the cap may cause leakage at these joints over the long term. Therefore, those alternatives with GCLs were eliminated from further evaluation.

Based on the alternative screening, three alternatives will be carried into the Detailed Analysis:

- Alternative 5 Single-Barrier FMC Cover
- Alternative 7 Single-Barrier FMC with a Low Permeability Soil Cover
- Alternative 9 Composite-Barrier with FMC and Clay Cover

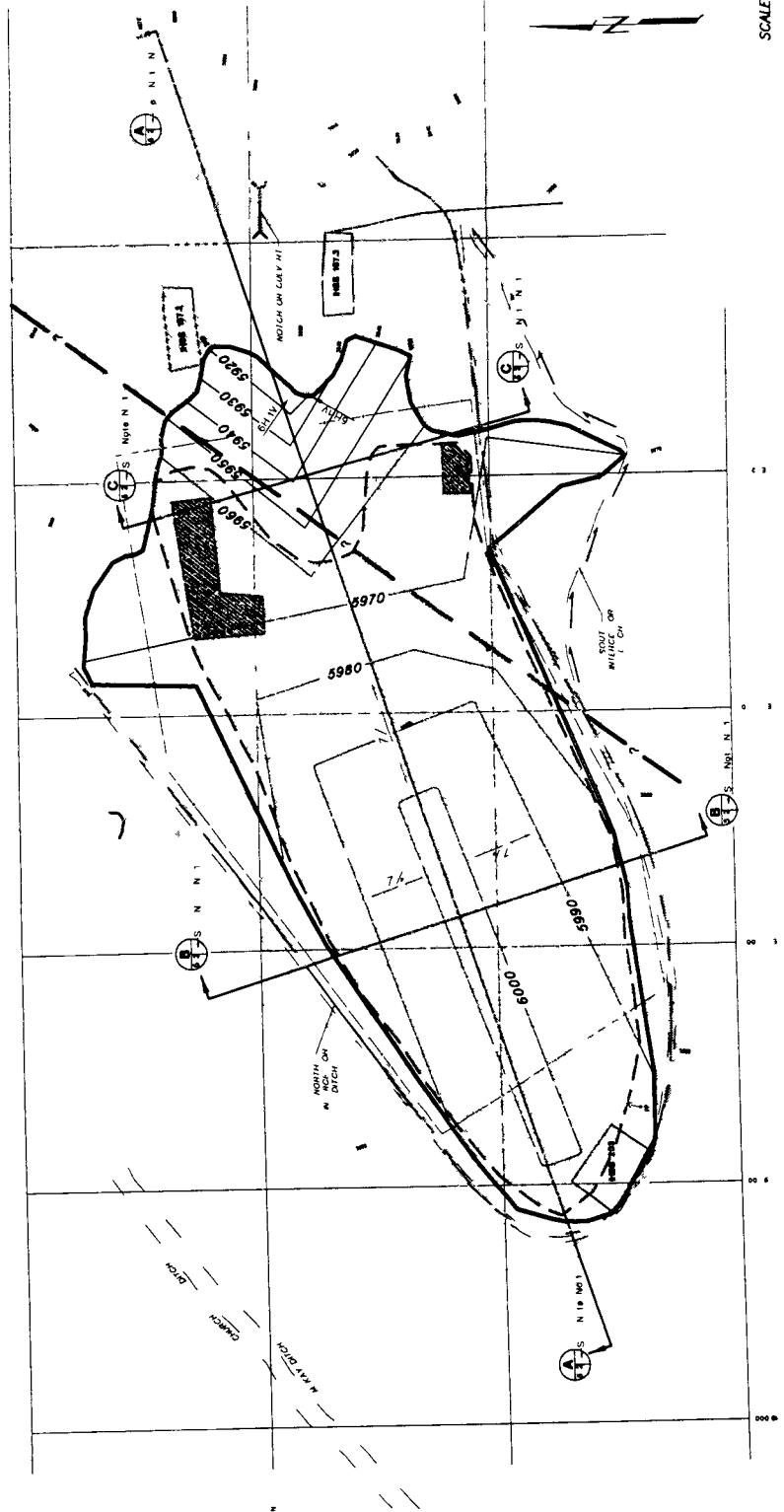
The No Action alternative is also retained as a baseline for comparison.

Table 5-1
Comparison of Effectiveness Factors

Alternative		Permeability (cm/sec)	Average Annual Leakage (in/year)
Alternative 1	No Action	1×10^2	1 4
Alternative 2	Institutional Controls	1×10^2	1 4
Alternative 3	Native Soil	1×10^2	1 1
Alternative 4	Single-Barrier Clay	1×10^7	1 0
Alternative 5	Single-Barrier FMC	1×10^{13}	0 021
Alternative 6	Single-Barrier GCL	3×10^9	0 035
Alternative 7	Single-Barrier FMC w/ Low Perm Soil	1×10^{13}	0 00016
Alternative 8	Composite-Barrier FMC & GCL	1×10^{13}	0 000000020
Alternative 9	Composite-Barrier FMC & Clay	1×10^{13}	0 00001

Table 5-2
Summary of Comparative Analysis

Alternative		Effectiveness	Implementability	Cost	Action
Alternative 1	No Action	Low	High	Low	Retain
Alternative 2	Institutional Controls	Low	High	Low	Eliminate
Alternative 3	Native Soil	Low	High	Low	Eliminate
Alternative 4	Single-Clay	Low	Low	High	Eliminate
Alternative 5	Single-FMC	Moderate	Moderate	Moderate	Retain
Alternative 6	Single-GCL	Low	High	Moderate	Eliminate
Alternative 7	Single-FMC with Low Perm Soil	High	Moderate	Moderate	Retain
Alternative 8	Comp-FMC & GCL	High	Moderate	High	Eliminate
Alternative 9	Comp-FMC & clay	High	Low	High	Retain



LEGEND

- FAULT
- DITCH
- CONCEPTUAL GRADING PLAN CONTOURS
- EDGE OF REGRADE AREA
(AREA 120.44 FT²)
- EDGE OF LANDFILL
(AREA 170.33 FT²)
- ▨ ASBESTOS AREA
(AREA 170.33 FT²)
- ▨ COVER AREA
(AREA 170.33 FT²)

SURSITE VOLUME TABLE UNADJUSTED

SURSITE	STRATUM	SURF 1	SURF 2	NET YARDS	NET YARDS	NET YARDS
01	CAP 1	NW	NW	982	232	124

NOTES:
 1) REFERENCED ON DRAWINGS J 2A AND 5 2B
 2) BASE TOPOGRAPHY AND FEATURES PROVIDED BY EC & G

DRAWING NO. WHERE
 THIS SECTION
 IS REFERENCED
 DETAIL/SECTION
 NUMBER
 DRAWING NO. WHERE
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 IS SHOWN

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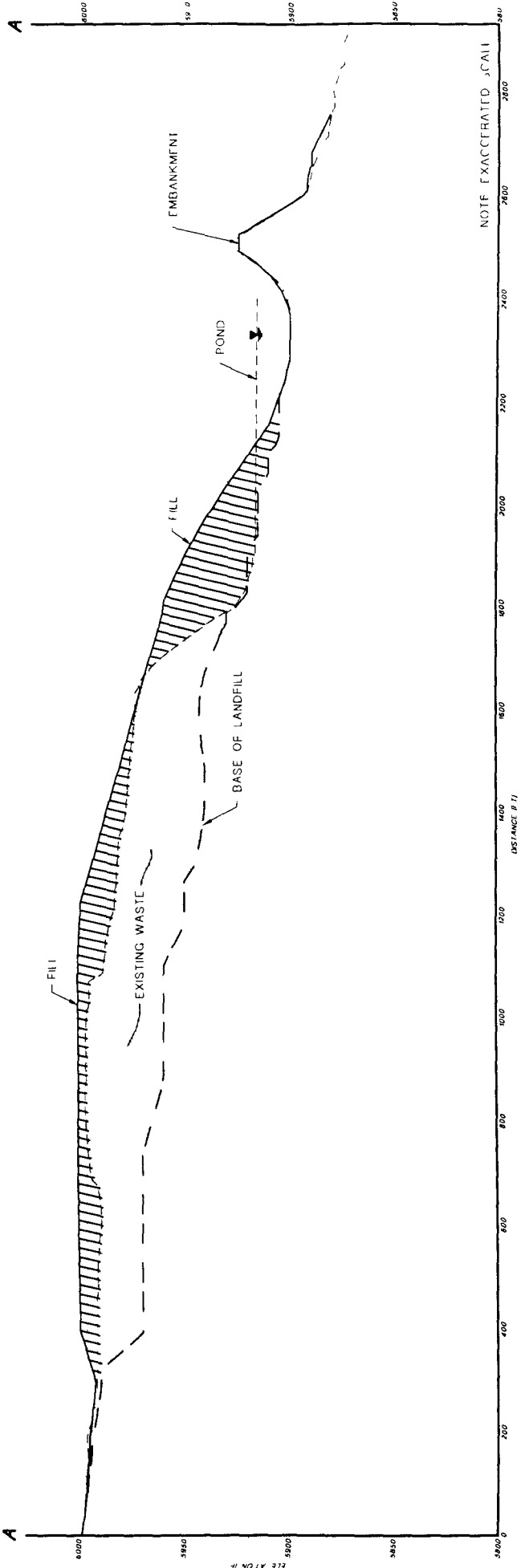
Proposed Conceptual Grading Plan, Extent of Cover, and Surface Water Control Plan

Phase 1 IM/IRA Operable Unit No. 7

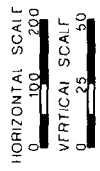
Date July 1995

Figure 5-2

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See Note No 1
A CROSS-SECTION A-A



LEGEND

- CURRENT SURFACE
- BASE OF LANDFILL SURFACE
- PROPOSED CONCEPTUAL GRADING PLAN
- ▨ FILL
- ▨ EXISTING LANDFILL

NOTE 1) REFERENCED ON DRAWING 5-2

DRAWING NO. WHERE
DETAIL/SECTION
IS REFERENCED

A

DETAIL/SECTION
NUMBER

DRAWING NO. WHERE
DETAIL/SECTION
IS SHOWN

US Department of Energy
 Rocky Flats Environmental Technology Site Golden Colorado

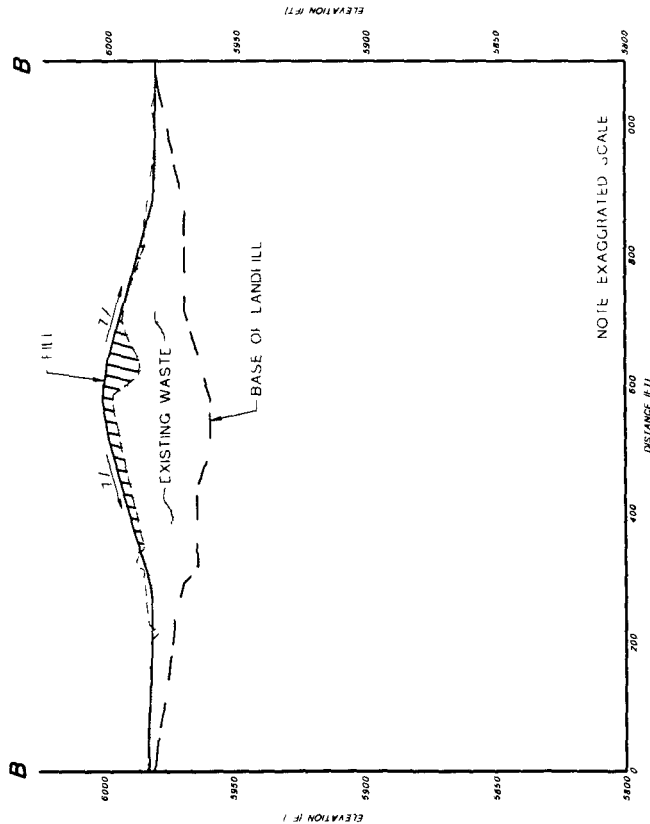
Landfill Cover Cross Section A-A'

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Figure 5 2A

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See Note No 1 **CROSS-SECTION B-B**

HORIZONTAL SCALE
0 100 200
VERTICAL SCALE
0 25 50

LEGEND

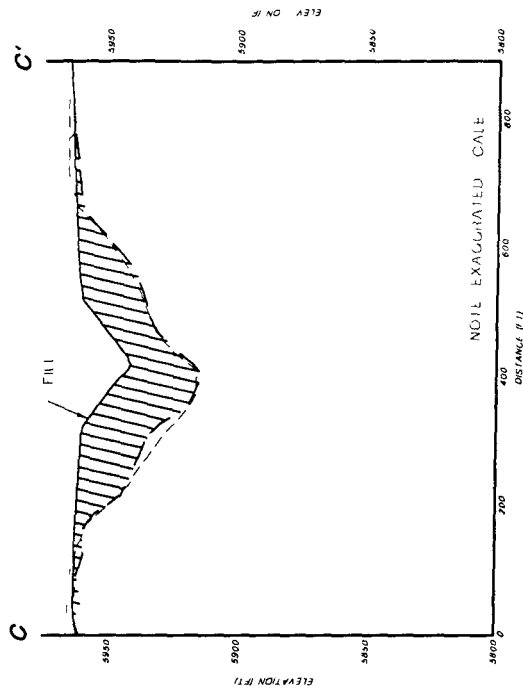
- CURRENT SURFACE
- BASE OF LANDFILL SURFACE
- PROPOSED CONCEPTUAL GRADING PLAN
- FILL
- EXISTING LANDFILL

NOTE
1) REFERENCED ON DRAWING 5 2

DRAWING NO. WHERE
DETAIL/SECTION
IS REFERENCED

A
DETAIL/SECTION
NUMBER

DRAWING NO. WHERE
DETAIL/SECTION
IS SHOWN



See Note No 1 **CROSS-SECTION C-C**

HORIZONTAL SCALE
0 100 200
VERTICAL SCALE
0 25 50

U.S. Department of Energy
Rocky Flats Environmental Technology Site Golden Colorado

Landfill Cover Cross Section B-B' & C-C'

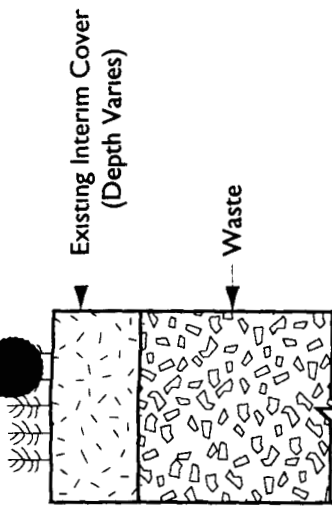
Phase I IM/IRA

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July 1995

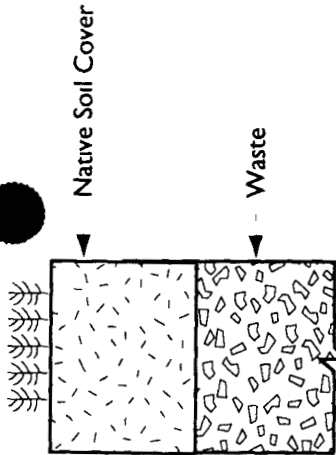
Figure 5-2B

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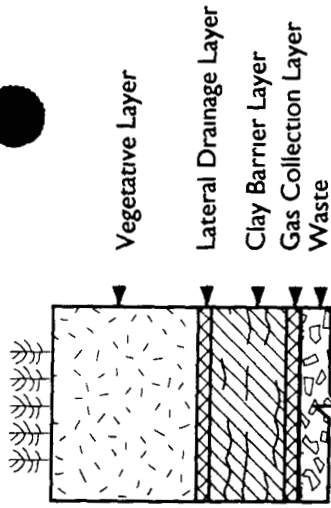


Alternative 1 No Action

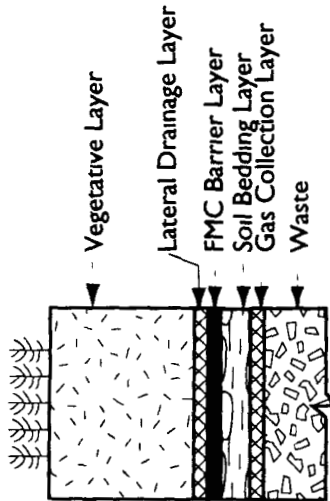
Alternative 2 Institutional Controls



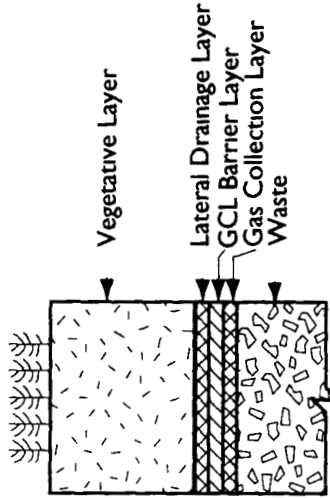
Alternative 3 Native Soil Cover



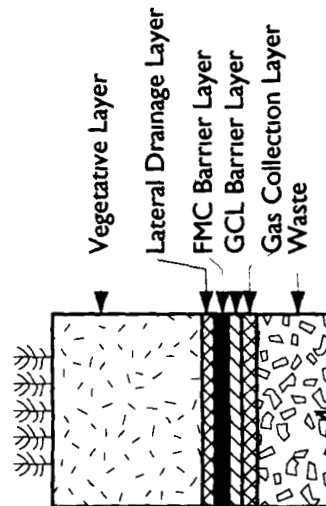
Alternative 4 Single Barrier - Clay



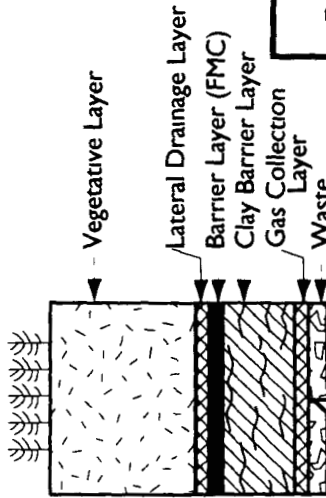
Alternative 5 Single Barrier - FMC



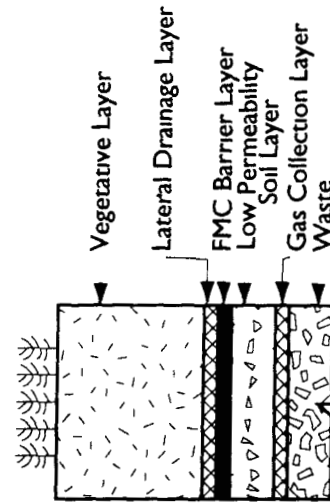
Alternative 6 Single Barrier - GCL



Alternative 8 Composite Barrier - FMC and GCL



Alternative 9 EPA's Composite Barrier - FMC and Clay



Alternative 7 Single Barrier - FMC and Low Permeability Soil

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Cover Cross Section Alternatives

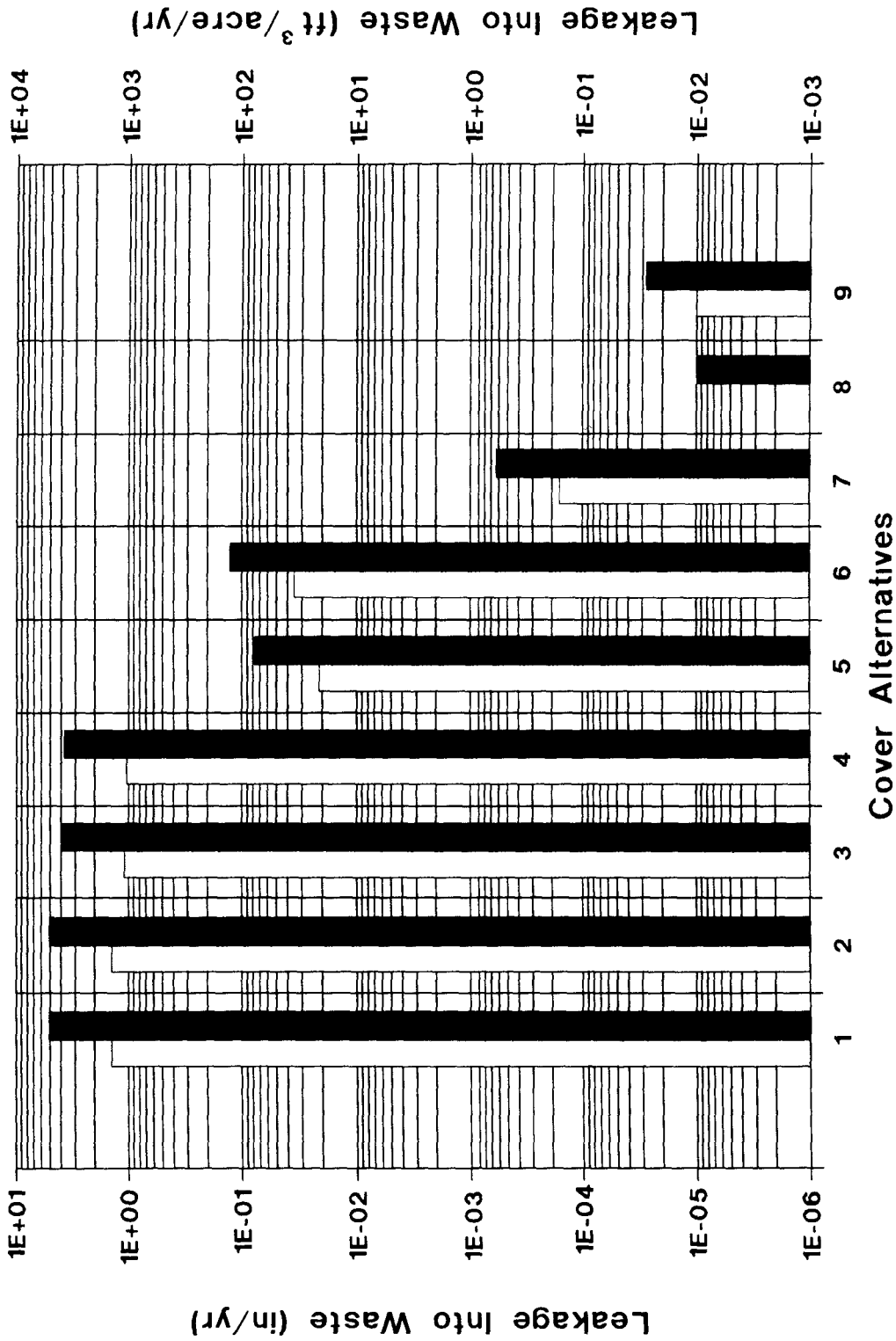
Phase I IM/IRA

Operable Unit No. 7

Date July 1995

Figure 5-3

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OU 7 HELP ANALYSIS Evaluation of Cover Components

1 IM/IRA Operable Unit No. 7

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Figure

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6. Detailed Analysis of Alternatives

Four alternatives are carried through the screening process presented in Section 5

- Alternative 1 No Action
- Alternative 5 Single-Barrier FMC Cover
- Alternative 7 Single-Barrier FMC with Low Permeability Soil Cover
- Alternative 9 Composite-Barrier FMC and Clay Cover

The purpose of the Detailed Analysis is to analyze these alternatives in enough detail so that decision makers are able to select the most viable alternative for OU 7. The No Action alternative is retained as a baseline for comparison.

6.1 Screening Process

The NCP identifies nine criteria to be used in the detailed analysis. The EPA separates the criteria into three groups. The first two criteria are considered threshold criteria and must be met. The next five criteria are used to compare the alternatives and balance the pros and cons. The final two criteria will be evaluated by the EPA after the public comment period and incorporated into the ROD. The nine criteria are:

Threshold Criteria

- 1 Overall Protection of Human Health and the Environment
- 2 Compliance with ARARs

Primary Balancing Criteria

- 3 Long-term Effectiveness and Permanence
- 4 Reduction of Toxicity, Mobility, and Volume through Treatment
- 5 Short Term Effectiveness
- 6 Implementability
- 7 Costs

Modifying Criteria

- 8 Regulatory Agency Acceptance
- 9 Community Acceptance

Each of the criteria is broken down into specific factors to facilitate consistent analysis of alternatives. The factors are briefly summarized in the following sections:

6 1 1 Overall Protection Of Human Health And The Environment

There is only one factor sighted for this threshold criterion

- Provisions for human health and the environment protection

Evaluation of overall protectiveness draws on long and short term effectiveness and compliance with ARARs. It should address the method of reducing site risk in terms of the RAOs

6 1 2 Compliance With ARARs

This criterion is defined by the following factors

- Compliance with chemical-specific ARARs
- Compliance with action-specific ARARs
- Compliance with location-specific ARARs
- Compliance with other criteria, advisories and guidance

Alternatives are evaluated to determine if they meet all ARARs presented in Section 3 and if not, if a waiver is possible

6 1 3 Long-Term Effectiveness and Permanence

The following factors are used to define this criterion

- Magnitude of residual risk
- Adequacy and reliability of controls
- This criterion is used to assess the results of the remedial action. The evaluation addresses the risks remaining after treatment or due to untreated waste and the level of certainty that the proposed action is reliable over the 30 year post-closure period

6 1 4 Reduction of Toxicity, Mobility, and Volume through Treatment

The key factors comprising this criterion are

- Treatment process used and materials treated
- Amount of hazardous materials destroyed or treated
- Degree of expected reductions in toxicity, mobility and volume
- Degree to which treatment is irreversible
- Type and quantity of residuals remaining after treatment

This criterion addresses the statutory preference for treatment technologies that produce a significant, permanent reduction in toxicity, mobility, or volume of a hazardous substance

6 1 5 Short Term Effectiveness

The primary factors used in analysis of short-term effectiveness are

- Protection of community during implementation of remedial actions
- Protection of workers during implementation of remedial actions
- Environmental impacts during implementation of remedial actions
- Time until remedial action objectives are achieved

Short-term effectiveness addresses the risks posed during construction and implementation of the remedial action

6 1 6 Implementability

The factors that make up the implementability criterion are grouped into three areas technical feasibility, administrative feasibility and the availability of services and materials The factors are

- Technical feasibility
 - Ability to construct and operate the technology
 - Reliability of the technology
 - Ease of undertaking additional remedial actions if necessary
 - Ability to monitor effectiveness of the remedy
- Administrative feasibility
 - Ability to obtain approvals from regulatory agencies
 - Coordination with other agencies
- Availability of services and materials
 - Availability of offsite treatment, storage and disposal services and capacity
 - Availability of necessary equipment and specialists
 - Availability of prospective technologies

6 1 7 Costs

Cost estimates are developed for each alternative A present worth analysis is used to discount all future costs to the current year to facilitate comparison among alternatives The present worth costs are based on a 3 percent discount rate over a 30 year closure period

The cost estimate includes

- Capital costs
- Operating and maintenance costs
- Total present worth cost

6 1 8 Regulatory Agency Acceptance

The regulatory agency acceptance criterion addresses the concerns of CDPHE and EPA. This criteria is not included in this document but is addressed in the ROD.

6 1 9 Community Acceptance

This criterion addresses concerns raised by the public. As with regulatory acceptance, this is incorporated into the ROD.

6.2 Evaluation of Alternatives

Each of the four alternatives are evaluated based on the seven criteria.

6 2 1 Alternative 1 No Action

6 2 1 1 *Description*

Under Alternative 1, no action is taken. The No Action alternative is required under the NCP and provides a baseline for comparison of other alternatives.

6 2 1 2 *Evaluation*

Overall Protection of Human Health and the Environment

None of the RAOs or closure requirements are met under the No Action alternative. Potential risks to human health and the environment are not addressed and will not be monitored. Because no action is taken, there are no short term effects.

Compliance with ARARs is discussed in Section 3.4.

Chemical specific ARARs

Leachate exceeds chemical-specific ARARs for nine analytes, however, DOE proposes to delist the leachate which is F039 RCRA-listed waste contained in groundwater. Surface water exceeds one ARAR for vinyl chloride. This data point is considered an outlier and therefore surface water is considered in compliance. Four analytes exceed ARARs in UHSU groundwater downgradient of the landfill: selenium, chloride, nitrate/nitrite, and sulfate. Based on flow modeling, particle tracking, and contaminant

transport modeling (Appendices C and E), exceedance of ARARs at the three downgradient groundwater monitoring wells is not expected

[TerraMatrix-air requirements]

Action-specific ARARs requiring the closure of the landfill are not being met

The No Action alternative poses no threat to wetlands or potential Preble's meadow jumping mouse habitat. Therefore, it is in compliance with location-specific ARARs.

Long-Term Effectiveness and Permanence

The No Action alternative does not reduce the risk at the site. Existing interim cover and fencing will degrade and become ineffective over time. The average annual leakage rate for the No Action alternative is 1.41 inches. A discussion of leakage rates is in Appendix G.

Reduction of Toxicity, Mobility, and Volume through Treatment

The No Action alternative relies on natural biodegradation for any reductions in toxicity or mobility. There is no expected reduction in volume.

Short-term Effectiveness

No construction or implementation is required, therefore, there are no short-term impacts to the community, workers or the environment. The RAOs will not be achieved during the 30 year life of the project.

Implementability

The No Action alternative requires no technical implementation, however, because it does not meet closure regulations, administrative approval is unlikely.

Costs

The costs for Alternative 1 No Action are

Total Capital Cost Periodic	\$0
Annualized Annual/Periodic O&M Cost	\$0
Total Present Worth Cost	\$0

6 2 2 Alternative 5 Single-Barrier FMC Cover

6 2 2 1 Description

Alternative 5 consists of a single barrier FMC cover and institutional controls. The existing dam is left in place to contain groundwater migration. Institutional controls, including use and access restrictions, are discussed in detail in Section 5 2 2. The barrier layer is made up of an FMC with a permeability of approximately 10^{-13} cm/sec. Approximately 770,000 SF of landfill and surrounding area will be covered in this design option. A cross section of this cover is shown in Figure 6-1.

Mobilization and Demobilization

Mobilization and demobilization of individual contractors takes place at different times during the construction period. Peak labor loading also varies between contractors depending on the type of work being performed. It is not uncommon for geosynthetic contractors to have several mobilizations and demobilizations during a liner or closure project. This enables earthwork contractors, whose mobilization/demobilizations are more costly, to perform their work in a continuous fashion.

Site Preparation

Water levels in the East Landfill Pond must be lowered in order to provide access for cover construction and slope stabilization activities. The existing pumping system which is used to pump pond water to the A-Ponds will be used. The required final water level elevation is based on final cover extent and slope buttress design.

Soil material is required to buttress unstable slopes. It is placed by first establishing a bench of material on the lower toe of slope areas. Additional material then is placed in uniform lifts gradually proceeding up slope until the design elevation is reached. Trimming operations begin at the top of the slope and progress downwards to remove excess material.

A geosynthetic storage area is designated near the construction zone. Geotextile material is shipped in plastic covers to protect the material from truck exhaust fumes, road grit, and solar degradation. Material deliveries are inspected and sampled for conformance testing. Geosynthetics rolls are stacked on heavy wooden pallets above the ground surface to protect the material from dirt and mud. The stacks are arranged to allow easy access for handling and sampling.

Rerouting of the Surface Water Diversion Ditch

The existing perimeter surface water diversion ditch will be incorporated into the cover design to collect surface water runoff from the cover as well as intercepting surface

water runoff to the landfill. The capacity of the existing ditch will be compared to the expected design flows as part of the final design. Select portions of the perimeter ditch may have to be relocated to accommodate the grading plan (see Figure 5-2).

Landfill Cap

Fill layer

Construction of the cover begins with placement of general fill. Thickness varies from 3 to 15 feet, depending on the grading plan, which is designed to promote drainage off of the cover to the perimeter drainage ditch. In central areas of the cell, where design elevations are greatest, the fill is thickest. In lower elevation areas near the perimeter of the cell, fill is thinner.

The thickness of the general fill may also be affected by the final waste fill configuration. It is assumed here that additional waste placement in OU 7 will not take place once the new site landfill is operational. The grading of the fill layer is determined by two factors: the upper bound for the slope is based on stability and erosion control and the lower bound is to provide adequate surface water drainage after settlement as discussed in Section 5.1.3. Based on these conditions, approximately 225,000 CY of fill will be placed.

It is likely that site alluvial materials are satisfactory borrow sources for fill material. Special preparation of this material is generally not required, except for the top six inches of the placed layer. In this area, the fill material should be free of rocks or particles larger than 1 inch in order to prevent puncture of the gas collection system geosynthetics.

Gas Collection Layer

A composite made up of geonet with filter fabric on each side is rolled out over the general fill for gas collection. The composite panels are overlapped, heat bonded, or tied together. The geonet is sandwiched between two layers of filter fabric to prevent fines from clogging the geonet.

Gas vents will extend through the cover section and vent at the surface at regular intervals. The vents are expected to consist of PVC or HDPE pipe (depending on the FMC material selected).

Gas monitoring will be conducted in accordance with the post-closure plan.

Soil Bedding layer

Soil bedding is placed on top of the upper gas collection filter fabric in a one-foot or thicker lift using low ground pressure bulldozers. The surface of the soil layer is then trimmed with motor graders and compacted with a smooth drum vibratory roller to provide a smooth firm surface upon which to place the FMC.

FMC layer

The FMC geomembrane is rolled out and seamed using both fusion welding and extrusion welding techniques. Long straight seams are fusion seamed while extrusion welding is used in smaller, confined areas or where sharp turns in the weld are required. Patches for destructive seam sample areas and fusion welder entry and exit holes are examples of extrusion weld applications.

Destructive and nondestructive testing is performed on the geomembrane seams to document seam strength and seam integrity. Samples of the seam are extracted and pulled apart in a tensiometer to test the weld strength. Vacuum box tests and seam air pressure tests are used to determine if the seam is air tight.

Drainage Layer

The drainage layer composite geonet and filter fabric is placed over the FMC. The lower filter fabric provides a cushion so that the geonet does not damage the FMC. Panels are overlapped, heat bonded, or tied together.

Vegetative and Top Soil Layers

Placement of soil material on geosynthetics can cause damage to the geosynthetics if not done properly. Typically, soil material is placed in thick lifts, generally 2 feet to 3 feet, and spread with low ground pressure equipment. Care must be taken not to cause the geosynthetic material to wrinkle during soil placement and to maintain adequate lift thickness to reduce the chance of puncturing the material.

Top soil fertilizer and seeding complete the cover construction. Top soil can be readily acquired from local off site sources or, potentially, on site sources could be amended with soil additives to create a suitable vegetative substrate. Revegetation will take place in late fall. Seeds lay dormant through the winter and germinate the following spring.

Decontamination

Decontamination activities for personnel and equipment are expected to be minimal because no waste excavation is planned. However, air quality monitoring is conducted

periodically by contractor and site personnel to ensure that workers are not exposed to potentially hazardous materials. If monitoring indicates the presence of hazardous materials, appropriate personal protective equipment (PPE) will be used and decontamination procedures will be followed. This may include the establishment of different contamination level zones and contamination reduction zones in the OU 7 work area.

Certification of Final Closure

Construction activities are typically summarized in a final certification report, which is prepared by the third party CQA contractor. All facets of the cover installation, material testing, and final as-built drawings, etc. are included in this agency deliverable report.

6.2.2.2 Evaluation

Overall Protection of Human Health and the Environment

The Single Barrier-FMC Cap Alternative meets all RAOs. The cap, fence and institutional controls prevent direct contact with landfill contents. The cap has a permeability of approximately 10^{-13} cm/sec and therefore minimizes infiltration and resulting contaminant leaching to groundwater. The surface is graded and revegetated to control surface water runoff and erosion. A gas collection system controls landfill gas and has the capability for adding treatment if determined necessary.

Properly installed and maintained, the FMC will provide protection over the 30 year life of the project. Short term impacts due to implementation are minimal and easily mitigated. The alternative meets all ARARs.

Compliance with ARARs

Chemical-specific ARARs for leachate, surface water, and groundwater downgradient of the landfill are discussed in Section 3.4.

The Single Barrier-FMC Cap meets the action-specific ARARs identified in Section 3.4. This includes the following requirements for landfill closure [6 CCR 1007-3 Part 265.310]:

1. Provide long-term minimization of migration of liquids through the closed landfill.
2. Function with minimum maintenance.
3. Promote drainage and minimize erosion or abrasion of the cover.
4. Accommodate settling and subsidence so that the cover's integrity is maintained.

- 5 Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoil present

The natural subsoil under the landfill has a permeability of 10^{-6} to 10^{-7} cm/sec. The alternatives cap has a permeability of approximately 10^{-13} cm/sec. Although it meets all the regulatory requirements, this cap does not follow EPA's guidance for a RCRA Subtitle C cap, which suggests a composite barrier with FMC and clay layers as presented in Alternative 9.

The cap extends over areas identified as wetlands by the U.S. Army Corps of Engineers and potential habitat for the Preble's meadow jumping mouse (see Section 3). Approximately eight acres for the wetlands mitigation site at the SLPP have been proposed for mitigation of wetlands at OU 4, 5, and 7. Under the guidance of the U.S. Fish and Wildlife Service, DOE is attempting to determine if the Preble's mouse habitat exists at OU 7. If it is determined that Preble's habitat will be injured, DOE will mitigate losses.

Long-term Effectiveness and Permanence

The landfill, which is the source of contamination, remains in place. However, risks associated with the direct contact and leaching of source contaminants into the groundwater are minimized by the cap and institutional controls.

The FMC cap is considered a proven technology and if properly installed and maintained is effective over the 30 year life of the project. The cap is designed to prevent breaching from settling, erosion and freeze thaw cycles. The average annual leakage rate for this alternative is 0.021 inches. A discussion of leakage rates is in Appendix G.

Maintenance of the cap is not difficult or labor intensive but inspections must be conducted on a periodic basis and if portions of the cap are damaged, must be repaired immediately. DOE is responsible for conducting routine biannual inspections of the final cover, surface water interceptor ditch, surveyed benchmarks, security fence, groundwater monitoring system, gas monitoring system, and the site fencing. DOE will repair any defects.

Long-term effectiveness will be monitored and additional measures taken as required. The groundwater monitoring system consists of Well 50094 upgradient of the landfill and Wells 52894, 52994, and 53094 downgradient of the landfill as shown in Figure 6-2. DOE will monitor the wells biannually as outlined in the closure plan.

The effectiveness of the remedial action will be evaluated every 5 years by EPA.

Reduction of Toxicity, Mobility, and Volume through Treatment

Although there is no treatment with this option, there may be some decrease in toxicity and mobility over time due to natural attenuation processes. The cap also decreases infiltration into the waste, which then limits the generation and migration of leachate.

Short-Term Effectiveness

The contaminants are currently under a 1- to 3-foot thick soil cover. No excavation into contaminated areas is required to implement this option. Therefore, risks to the community and site workers is minimal. The possibility exists that workers could be exposed to contamination accidentally during construction, however, this is unlikely and proper use of PPE limits such exposure.

The remedial action would result in dust generation during excavation, transport and placement of fill and the vegetative layer. The primary method of dust emissions control requires frequent periodic water spray of high traffic roadways, particularly to dirt or gravel roads. An alternative method is application of chemical polymer soil binders, but due to the short term nature of this project, this may not be justifiable from a cost standpoint.

During construction there is potential for increased erosion and therefore increased solids loading to the surface water drainage ditch. Erosion of the cover soil will diminish as vegetation proliferates on the surface. Until that time, however, berms and hay bales will be used to intercept surface water run-off and prevent the off-site transport of solids and erosional features such as drilling will need to be repaired. This post closure maintenance work will involve importation and placement of top soil material and earthwork equipment and manpower to spread material in the required areas. Extent of this repair work will be largely dependent on the severity of the weather.

As discussed in the ARARs section, this alternative has environmental impacts on wetlands and potential Preble's mouse habitat. These impacts will be mitigated by DOE.

Implementation, including design and construction takes approximately one year.

Implementability

Installing an FMC is a labor intensive operation that includes extensive CQA. However, industry standards are well developed and companies specializing in installation of geosynthetics are readily available.

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The long-term durability of FMCs have been evaluated through field testing of actual installations and through compatibility testing designed to simulate exposure to leachate for long periods of time in a laboratory. Both of the materials envisioned for use at OU 7, PVC and HDPE, have been proven to be reliable as barrier layers for at least the 30 year design life of the cover. In all of the cover options being considered, the FMC component will be covered with a 3-foot thick vegetative soil. This will prevent exposure to the UV radiation and from attack by roots and animals.

The FMC will be exposed to surface water that infiltrates through the vegetative cover soil and to some minor hazardous components in the migrating gases. The rain water is expected to be nonhazardous and the gases are expected to contain only limited concentrations of hazardous components.

Because the cap is the presumptive remedy for the landfill, it is unlikely that future action would be required to address the waste itself. It is more likely that containment, collection or treatment systems would be added to enhance the existing facility. In the event that additional remedial actions are required, alternatives could be developed that do not breach the cap or, if necessary, the cap could be excavated and replaced.

The effectiveness of the remedy will be monitored primarily through the post closure monitoring program as described in Section 8.

Costs

The costs for Alternative 5 Single-Barrier FMC cover are

Total Capital Cost	\$8,739,300
Annualized Annual/Periodic O&M Costs	\$72,400
Total Present Worth Cost	\$9,879,000

6.2.3 Alternative 7 Single Barrier- FMC with a Low Permeability Soil

6.2.3.1 Description

Alternative 7 consists of institutional controls and a composite barrier cover with FMC and a 12-inch layer of low permeability soil. The presence of the low permeability soil gives the cover system some of the benefits of a composite cover, without the strict installation requirements of a full clay liner. The existing dam is left in place to contain the groundwater. The barrier layer is a FMC with a permeability of approximately 10^{-13} cm/sec. This cover is shown in Figure 6-2.

This alternative is the same as Alternative 5 except that a low permeability soil replaces the soil bedding layer under the FMC. The first lift of soil is one foot thick and is placed using low ground pressure bulldozers. Subsequent lifts are placed in 6-inch to 9-inch thick lifts and compacted using sheepsfoot or wedgefoot compactors. The surface of the soil is then trimmed. Material placed is tested for moisture content, compaction, and conformance with source material index tests.

Overall Protection of Human Health and the Environment

This alternative provides protection of human health and the environment by meeting all the RAOs. The FMC prevents direct contact with landfill contents by means of the cover and extensive security measures limit access to RFETS and OU 7. The cap minimizes infiltration and in conjunction with the new slurry wall limits contaminant leaching to groundwater. The cover is designed to direct the majority of the surface water runoff to the surface water diversion ditch and the remainder to the East Landfill Pond. The cover is graded and vegetated to limit erosion to 2 tons/acre/year. A landfill gas collection layer and venting system is installed as part of the cap to protect its integrity. The design accommodates future landfill gas treatment if determined necessary during post closure monitoring.

The FMC is relatively easy to install and the low permeability layer provides additional barrier without the strict installation requirements of clay. The cap provides protection over the 30 year life of the project. Short term impacts to the community, workers and the environment are minimal because there is no excavation of waste.

The alternative meets all ARARs.

Compliance with ARARs

Chemical-specific ARARs are discussed in Section 3.4.

The Single Barrier-FMC with Low Permeability Soil Cap alternative meets the action-specific ARARs identified in Section 3 and discussed in Alternative 5. The cap has a permeability of approximately 10^{-13} cm/sec and thus meets the closure requirement for a permeability less than the natural subsoil under the landfill. Although it meets all the regulatory requirements, this cap does not meet EPA's guidance for a RCRA Subtitle C cap as presented in Alternative 9.

As with all the alternatives except No Action, the cap extends over areas identified as wetlands by the U.S. Army Corps of Engineers (see Section 3) and potential habitat for the Preble's meadow jumping mouse. DOE will mitigate these losses to be in compliance with location-specific ARARs as described under Alternative 5.

Long-Term Effectiveness and Permanence

As directed under the presumptive remedy, the source of contamination remains. However, risks associated with the direct contact and leaching of source contaminants into the groundwater is minimized by the cap and institutional controls. EPA will evaluate the effectiveness of the remedial action every 5 years.

The FMC barrier is considered a proven technology and if properly installed and maintained is effective over the 30 year life of the project. In addition this alternative has a second, low permeability layer to act as backup. The average annual leakage rate for Alternative 7-Single Barrier-FMC with Low Permeability Soil is 0.00016 inches. A discussion of cap leakage rates is in Appendix G.

The maintenance and monitoring are the same as discussed under Alternative 5.

Reduction of Toxicity, Mobility, and Volume through Treatment

There is no active treatment with this option. However, there may be some decrease in toxicity and mobility over time due to natural attenuation processes. Leachate generation and migration will be limited by the cap.

Short Term Effectiveness

No excavation into contaminated areas is required to implement this Alternative. The contaminants are currently under a 1 to 3 foot thick interim soil cover. Therefore risks to the community and site workers is minimal. The possibility exists that workers could be exposed to contamination accidentally, however, proper use of PPE would limit potential exposure.

Dust is generated during excavation, transport and placement of fill, the low permeability soil layer and the vegetative layer. The dust emissions are controlled by water spraying or possibly soil binders. Erosion during construction is controlled by berms and hay bales.

As discussed in the ARARs section, this alternative has environmental impacts on wetlands and potential Preble's mouse habitat. These impacts will be mitigated by DOE.

Cap construction would be complete within one year.

Implementability

The addition of the low permeability soil does not add significantly to the installation of this cap in comparison with the FMC barrier as discussed under Alternative 5. The

low permeability soil will be placed on top of the gas collection layer and spread in a single 1-foot lift. The surface of the 1-foot lift will be compacted and rolled to form a smooth, low permeability surface for placement of the FMC. Some minor grading of the low permeability soil may be required to maintain surface grades and prevent ponding.

Costs

The cost for Alternative 7 Single-Barrier FMC with Low Permeability Soil Cover are

Total Capital Cost	\$9,327,500
Annualized Annual/Periodic O&M Costs	\$72,400
Total Present Worth	\$10,467,200

6 2 4 Alternative 9 Composite Barrier-FMC and Clay

6 2 4 1 Description

Alternative 9 is a composite barrier with both FMC and a 24-inches of compacted clay. As with all the alternatives, the existing dam is left in place to contain groundwater migration away from the source. Use and access restrictions are discussed in Section 5 2 2. The design follows EPA guidance for a RCRA Subtitle C facility. This cover is shown in Figure 6-3.

This cover differs from Alternative 5 in that a clay barrier layer with a permeability of approximately 10^{-7} cm/sec replaces the soil bedding. Clay must be transported from off site, processed and conditioned as discussed in Section 5 3 5 2. Then prepared clay material is placed on top of the upper gas collection layer filter fabric in a 1 ft or thicker lift using LPG bulldozers. Subsequent lifts are placed in 6-inch to 9-inch thick lifts and compacted using sheepsfoot or wedgefoot compactors. The surface of the clay layer is tested and scarified to increase bonding between lifts.

During placement, care must be taken to protect the clay from moisture loss during dry periods or over moisturizing during rainy periods. Once the clay is placed and before it is covered with the geomembrane, similar steps must be taken to prevent desiccation, over moisturizing, or erosion.

6 2 4 2 Evaluation

Overall Protection of Human Health and the Environment

The Composite-Barrier FMC and Clay Cover Alternative meets all RAOs. The cap, fence and institutional controls prevent direct contact with landfill contents. The cap has a permeability of approximately 10^{-13} cm/sec and therefore minimizes infiltration and resulting contaminant leaching to groundwater. The surface is graded and revegetated to control surface water runoff and erosion. A gas collection system controls landfill gas and has the capability for adding treatment if determined necessary.

The compacted clay liner provides a secondary barrier, however, it requires intensive effort to properly install. The cap provides protection over the 30 year life of the project. Because there is no planned excavation into landfill waste, short term impacts are minimal. The alternative meets all ARARs.

Compliance with ARARs

A detailed discussion of chemical-specific ARARs is in Section 3.4. Chemical-specific ARARs are the same for all alternatives.

The EPA Composite Cap meets the action-specific ARARs identified in Section 4 and discussed in Alternative 5. The cap has a permeability of approximately 10^{-13} cm/sec and thus meets the closure requirement for a permeability less than the natural subsoil under the landfill. This design follows EPA's guidance for a RCRA Subtitle C cap.

DOE will address location-specific ARARs associated with this alternative, including wetlands and potential habitat for the Preble's meadow jumping mouse. DOE has proposed mitigating the wetland losses as part of the SLPP. DOE will also mitigate losses to Preble's mouse habitat.

Long-term Effectiveness and Permanence

The source of contamination remains on site. However, the cap and institutional controls minimize risks associated with direct contact and leaching of source contaminants into the groundwater. Every 5 years, EPA will evaluate the effectiveness of the action.

Both the FMC and clay barriers are considered proven technologies. If properly installed and maintained they are effective over the 30 year life of the project. However, the compacted clay layer is subject to desiccation and cracking. The 5 year average annual leakage rate for Alternative 9- Composite Barrier - FMC and Clay is 0.00001 inches. A discussion of cap leakage rates is in Appendix G.

The schedule for maintenance and monitoring is the same for all capping alternatives and is discussed under Alternative 5.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative does not include active treatment. However, as with the other alternatives, there may be some decrease in toxicity and mobility over time due to natural attenuation processes. In addition, the cap minimizes infiltration into the waste thus decreasing generation and migration of leachate.

Short Term Effectiveness

As with the other alternatives, no excavation into contaminated areas is required to implement this Alternative. The contaminants are currently under a 1- to 3-foot-thick interim soil cover. Therefore, risks to the community and site workers is minimal. Workers could be exposed to contamination accidentally during construction, however, proper use of PPE would limit exposure.

This remedial action results in dust generation during excavation, transport and placement of fill, clay and vegetative layer. The dust emissions are readily mitigated using standard dust suppression techniques.

Erosion during construction is addressed by using hay bales and berms.

As discussed in the ARARs section, this alternative has environmental impacts on wetlands and potential Preble's mouse habitat. These impacts will be mitigated by DOE.

Cap construction could be complete within one year.

Implementability

The installation of the clay barrier layer requires significant effort. The clay material must be mined, sized, moisture conditioned, and allowed to cure before it can be placed.

Costs

The costs for Alternative 9 Composite-Barrier FMC and Clay Cover are

Total Capital Cost	\$11,018,600
Annualized Annual/Periodic O&M Costs	\$72,400
Total Present Worth Cost	\$12,158,300

6.3 Comparative Analysis

In the previous sections, each of the alternatives is evaluated individually against the seven CERCLA criteria. This section provides a relative comparison of their performance based on the same criteria. The purpose of this analysis is to identify the strengths and weaknesses relative to each other. The comparative analysis is summarized in Table 6-1.

With the exception of the No Action Alternative, all the alternatives meet the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs. Reduction of Toxicity, Mobility, and Volume through Treatment, a primary balancing criterion, is the same for all alternatives since none of the remedial actions include treatment. All of the alternatives are compared based on the remaining primary balancing criteria: long-term effectiveness and permanence, short term effectiveness, implementability, and cost.

The focus is on the soil layer beneath the geomembrane, which is the only difference among the three alternatives.

6.3.1 Long Term Effectiveness and Permanence

For long term effectiveness, the focus is on the two main functions of the soil layer beneath the geomembrane:

- the ability of the soil to support and enhance the function of the geomembrane
- the long term permeability of the soil barrier itself

The soil bedding layer of Alternative 5 serves to support the FMC as do the low permeability soil layer and the clay barrier layer; however, should a breach in the membrane take place, the bedding soil layer would not impede the movement of liquids as well as either the low permeability soil or the clay barrier layer. On this basis, the bedding soil layer presents a higher long term risk than the other two alternatives.

The leakage rate for Alternative 5 is the highest of the three alternatives at 0.0213 cm/sec. Alternatives 7 and 9 have leakage rates of approaching zero.

Over the life of the project, the key difference between the low permeability soil and clay barrier is resistance to desiccation. Studies (Corser et al, 199_) indicate that covers constructed with clay materials at high moisture contents may be subject to greater desiccation than covers constructed of soil materials at lower moisture contents. The desiccation cracking provides pathways for liquids to travel through the clay barrier layer, thus increasing its permeability and reducing its long term effectiveness. The low permeability soil layer, which is placed at lower moisture contents, may have a

higher initial permeability when placed, but in the long term may be less permeable than the clay barrier layer due to its resistance to desiccation

6 3 2 Short-Term Effectiveness

None of the alternatives presents a significant danger to the community, workers, or the environment during construction. Alternatives 5, 7, and 9 may be differentiated in terms of dust generation and potential for erosion due to the varying quantities of soil. Alternative 5 has 6 inches or 14,365 CY of bedding soil. Alternative 7 has 12 inches or 28,531 CY of low permeability soil. Alternative 9 has 24 inches or 57,062 CY of compacted clay. In addition to having the greatest quantity of soil, the clay requires the greatest amount of working and therefore has the potential for the greatest dust generation.

6 3 3 Implementability

The three alternatives are compared in terms of technical feasibility, administrative feasibility and availability of services and materials.

6 3 3 1 *Technical feasibility*

Ability to Construct and Operate

The clay barrier in Alternative 9 is more difficult to construct than the low permeability soil layer or the bedding soil layer due to required moisture conditioning and maintenance of exposed clay during construction. The clay typically is moisture conditioned and allowed to cure on stockpiles in advance of scheduled placement in the cell. Care must be taken to protect the clay from moisture loss during dry periods or over moisturizing during rainy periods. Once the clay is placed and before it is covered with the geomembrane, similar steps must be taken to prevent desiccation, over moisturizing, or erosion.

Repairs are most easily made to Alternatives 5 and 7 because clay materials do not have to be prepared or maintained on site. If, in the future, new clay borrow sources are selected for Alternative 9 repair purposes, it may also be necessary to complete new test fill and chemical compatibility tests for that material.

Reliability of Technology

All three alternatives have an FMC barrier layer which has proven reliable in field and laboratory testing. Alternative 9 provides a second barrier for added reliability but the clay is subject to desiccation.

Ease of Additional Remediation

In the event that additional action is required, it is unlikely that the cap will interfere. However if action must be taken below the cap, Alternative 5 is simplest to repair and Alternative 9 the most complex.

Monitoring

Monitoring the condition of the cover will be the same for Alternatives 5, 7, and 9. Details of this monitoring are presented in the post-closure monitoring plan (Section 9).

6.3.3.2 Administrative feasibility

Proposed design alternatives that deviate significantly from suggested EPA guidance typically undergo high levels of scrutiny during technical review. Alternate 9, which most closely follows prescribed EPA guidance, would likely meet with the least opposition.

6.3.3.3 Availability of Services and Materials

Alternatives 5, 7, and 9 employ standard industry materials, equipment, and skilled labor types. On site clay borrow sources have not been located, however, clay materials are available from a local offsite supplier.

6.3.4 Costs

The total present worth costs for the alternatives are

Alternative 1	No Action	\$0
Alternative 5	Single-Barrier FMC Cover	\$9,879,000
Alternative 7	Single-Barrier FMC with Low Permeability Soil Cover	\$10,467,200
Alternative 9	Composite-Barrier FMC and Clay Cover	\$12,158,300

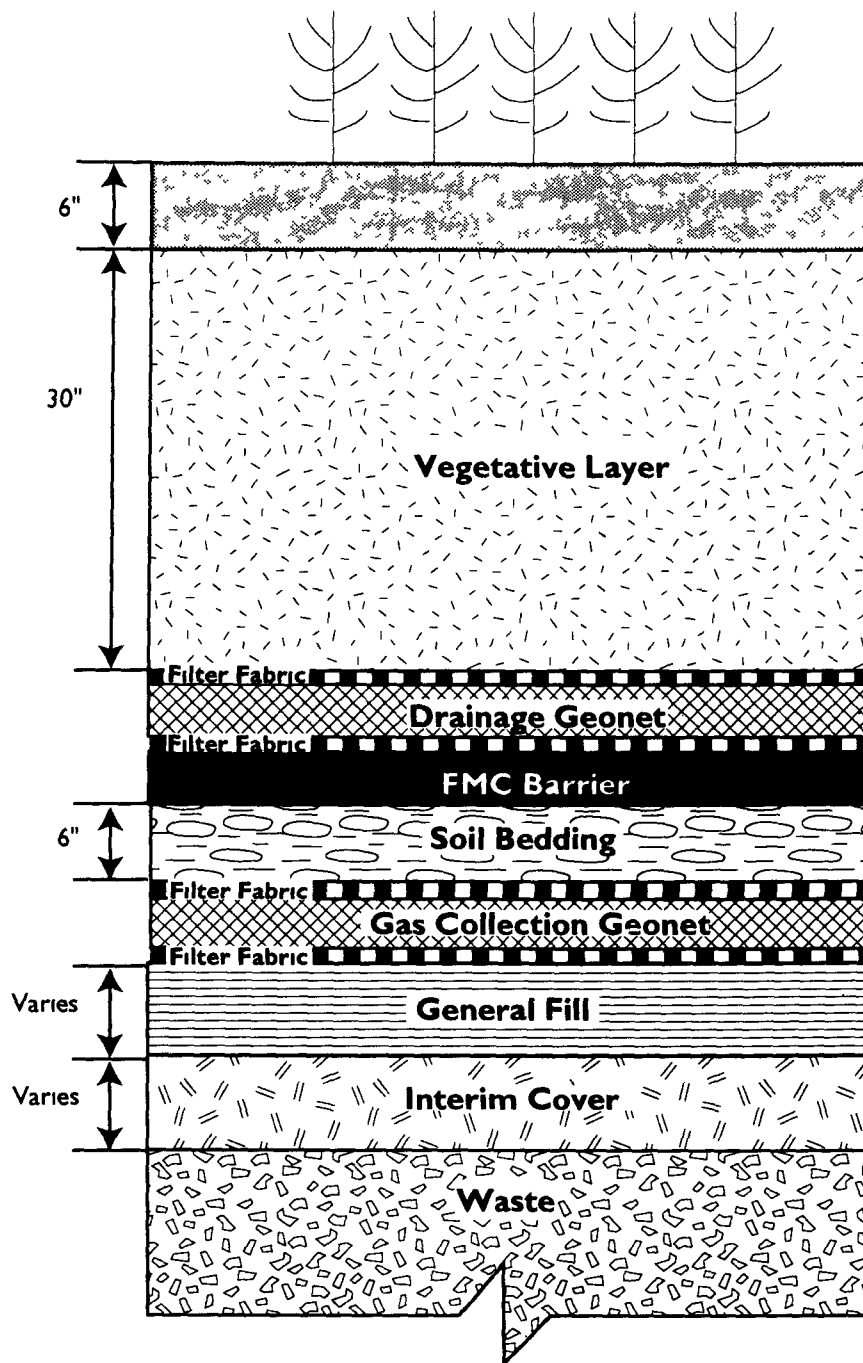
The O&M costs are the same for all alternatives because inspection, maintenance, and monitoring of the cover is the same for all capping alternatives. Periodic inspections will minimize any repairs to the barrier layer.

Alternative 7 is 5.6 percent higher than Alternative 5. Alternative 9 is 18.7 percent higher than Alternative 5 and 13.9 percent higher than Alternative 7.

6.3.5 Summary of Comparative Analysis

Table 6-1 summarizes the detailed evaluation of the alternatives. Each of the seven CERCLA criteria are weighted from 0 to 20 based on their relative importance. Then, each of the three alternatives are ranked based on performance for each criteria.

Weighting factors are multiplied by the rating to get a weighted score. The weighted scores are summed for each alternative. Alternative 7 has the highest total score and is the proposed alternative.



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Alternative 5: Single Barrier-FMC Cover Cross Section

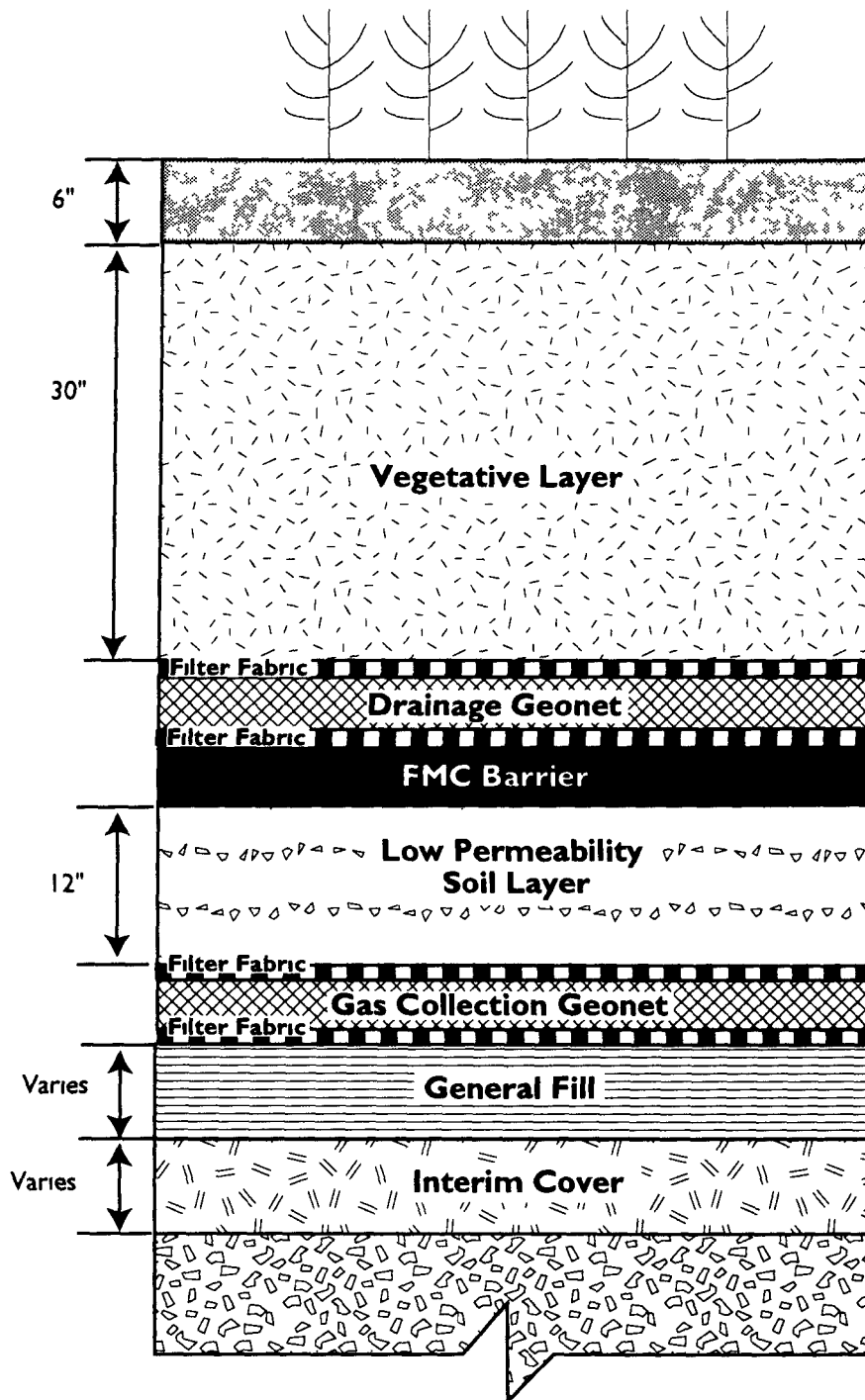
Phase I IM/IRA

Operable Unit No. 7

Date July 1995

Figure 6-1

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Rocky Flats Environmental Technology Site, Golden, Colorado

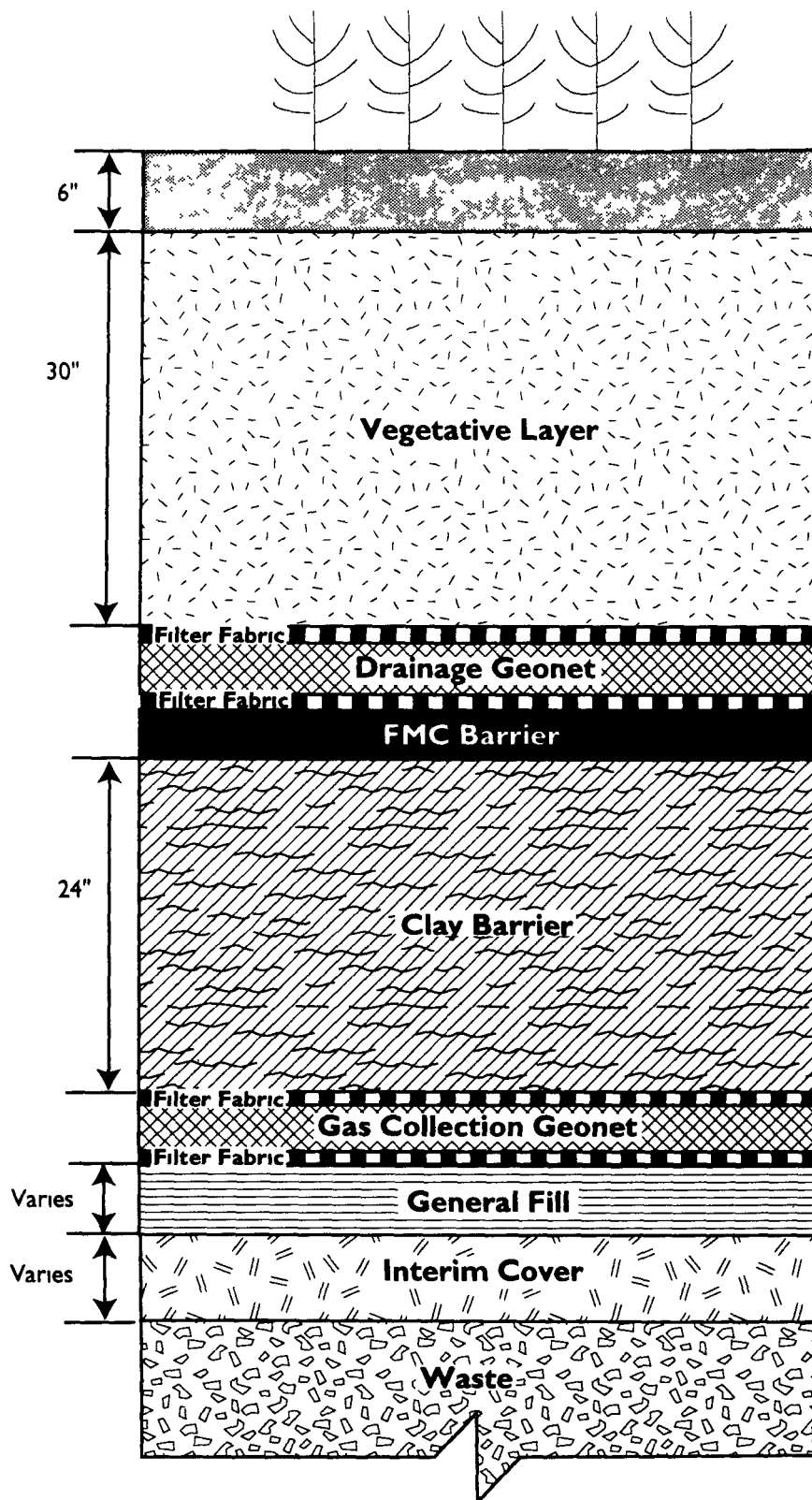
**Alternative 7: Single Barrier-FMC
& Low Permeability Soil
Cover Cross Section**

Phase I IM/IRA

Operable Unit No 7

Date July 1995

Figure 6-3



U S Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

**Alternative 9: Composite Barrier-FMC
and Clay
Cover Cross Section**

Phase I IM/IRA

Operable Unit No. 7

Date July 1995

Figure 6-4

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7. Conceptual Design

A conceptual design for the closure of the OU 7 Landfill has been prepared to identify the major design features of the closure plan and to address how the regulatory criteria will be met. Previous sections of this report have described the various alternatives that have been evaluated to select the closure components for the OU 7 facility. The objective of this section is to describe the components in detail and to identify how various regulatory criteria will be met. Design analyses have been completed to support the selection of the major design components and are described in this section. Additional design analyses will be completed as part of the final design. The approach and methodology for these additional design analyses is described in Section 7.1.

7.1 Regulatory Criteria

The presumptive remedy for CERCLA municipal landfill sites is related primarily to containment of the landfill mass and control and/or collection and treatment of landfill gas (EPA 1993a). In addition, measures to control landfill leachate, affected groundwater at the perimeter of the landfill, and/or upgradient groundwater that is causing saturation of the landfill mass may be implemented as part of the presumptive remedy. Presumptive remedy components for OU 7 include the Present Landfill (IHSS 114), Inactive Hazardous Waste Storage Area (IHSS 203), asbestos disposal areas, landfill gas, and F039 contained in groundwater within the source area.

Although the majority of the waste accepted at OU 7 is considered a municipal waste, some hazardous waste components have been detected in the leachate, indicating the presence of hazardous materials in the waste. Therefore, the specific criteria used for the landfill cover design are based on a RCRA, Subtitle C facility. EPA has issued various guidance documents on the design and construction of covers for hazardous waste facilities which are listed below along with the State of Colorado and Federal closure regulations.

- Colorado Hazardous Waste Regulations, 6 CCR 1007-3, Colorado Department of Health, August 1992,
- Title 40 - Code of Federal Regulations (40 CFR), Part 264,
- U.S. Environmental Protection Agency Technical Guidance Document: Covers for Uncontrolled Hazardous Waste Sites, EPA/540/2-85-002, September, 1985,
- U.S. Environmental Protection Agency Draft Minimum Technology Guidance on Double Liner Systems for Landfills and Surface Impoundments - Design, Construction and Operations, EPA/530-SW-85-014, April, 1987,

- U S Environmental Protection Agency Technical Guidance Document Final Covers on Hazardous Waste and Surface Impoundments, EPA/530-SW-89-047, July 1989
- U S Environmental Protection Agency Technical Guidance Document Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182, September, 1993

The State of Colorado regulations for hazardous waste landfill covers (6 CCR 1007-3) require the following

- Provide long-term minimization of migration of liquids through the closed landfill,
- Function with minimum maintenance,
- Promote drainage and minimize erosion or abrasion of cover,
- Accommodate settling and subsidence so that the cover's integrity is maintained, and
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present

The guidance criteria provided by EPA to achieve each of these objectives are summarized in Table 7-1, Summary of EPA Guidance Criteria for Design of Cover Systems

7.2 Conceptual Closure Plan Components

- Based on the presumptive remedy approach, the proposed conceptual closure strategy for each IHSS at OU 7 is as follows
- Present Landfill (IHSS 114) - single barrier cover
- Inactive Hazardous Waste Storage Area (IHSS 203) - single barrier cover
- Asbestos disposal area - single barrier cover
- Landfill gas - passive gas venting system
- FO39 contained in groundwater within the source area (seeps along east slope) - delist under CERCLA and provide for drainage under cover
- Upgradient surface water - diversion ditch

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Upgradient groundwater will be diverted around the landfill by the existing and proposed slurry walls. The specific components of the closure plan that are proposed to implement the presumptive remedies are presented in the following sections:

7.2.1 Proposed Grading Plan

The current filling plan for the OU 7 landfill envisioned mounding in the center of the landfill to provide surface water drainage to the perimeter of the waste before closure. However, given the current and projected waste inflow rates, the waste will not reach these design grades before closure of the facility in January 1997. Therefore, a large volume of general fill will be required to achieve grades that will drain surface water off of the facility and meet regulatory criteria.

Figure 7-2 shows the conceptual grading plan for OU 7 and Figures 7-3 and 7-4 indicate cross-sections through the OU 7 facility and indicate the extent of the fill areas.

The grading plan incorporates 7 percent surface grade across the majority of the landfill that drain to the perimeter. Along the east slope of the landfill, the grade steepens to approximately 6H 1V (9.5 degrees). Based on this plan, a total of approximately 225,000 cubic yards of fill material will be required to achieve the design grades.

The minimum surface grade is established based on the regulatory criteria of 3 to 5 percent minimum surface grades and the expected amount of surface settlement from placement of the general fill (to achieve design grades) and decomposition of the waste. Settlement of the OU 7 waste and fill materials was evaluated and although settlements will occur, they are expected to be relatively minor and should not affect surface drainage patterns causing abnormal erosion of the vegetative cover surface.

Settlements at various representative points on the landfill surface were estimated using a simple percent of thickness assessment, Sowers Method, Gibson and Lo Method, and power creep law. Details of the settlement analysis calculations are presented in Appendix 7-F. These methods yielded maximum settlements ranging from 2.9 to 5.5 feet in areas where the waste fill is thickest. The change in surface elevations resulting from these settlements was computed and the resulting surface slopes remained within the recommended 3 to 5 percent range.

Grasses and topsoil indigenous to RFETS will be used for the vegetative cover. Grasses include prairie grass, wheat grass, and green needle grass. It is expected that topsoil borrowed from site sources of the Flatirons soil formation can be amended with fertilizers to form a suitable substrate to establish cover vegetation. Erosion analyses using the Flatirons soil as a base, typical RFETS site climatic information, and the design topography indicate that the 6H 1V slopes surrounding the landfill pond will yield soil erosion rates of 1.8 tons/acre/year and the 7 percent slopes will yield 0.5

tons/acre/year after vegetation is established. These soil erosion rates are less than the maximum allowable value of 2 tons/acre/year, recommended by EPA guidance documents. Annual soil loss from erosion calculations with the associated methodologies and assumptions are presented in Appendix I. These erosion rates are not expected to cause abnormal sedimentation in the pond or perimeter ditches. It should be noted that this erosion analysis considered only average vegetation conditions and that a well established vegetative cover will reduce the erosion yields significantly.

The landfill cover will extend over the limits of the Present Landfill (IHSS 114), the Inactive Hazardous Waste Storage Area (IHSS 203), and the north and south asbestos areas. The limits of the cover are shown on Figure 7-2. In order to construct the cover over these areas and maintain minimum slopes, the general fill extends beyond the limits of the cover in some locations (see Figure 7-2).

As previously mentioned, the northeast slopes of the landfill that are extending down to the East Landfill Pond have experienced slumping and various seeps have been observed in the area. Due to the presence of these features, the grading plan has incorporated a large buttress fill in this area. The buttress fill in this area will result in 20 to 25 feet of material at the base of the slumps and will be sloped at approximately 6H 1V. In addition, it is envisioned that a blanket drain or system of French drains will be installed in and around the seep areas. The drains will collect and conduct the water out from under the cover and discharge into the East Landfill Pond. Preliminary stability analyses indicate that the effects of placing the buttress fill, reducing the slope from 3H 1V to 6H 1V, and installation of the subsurface drains will result in a long term stable slope.

The requirements for the general fill material that will be used to achieve the design grades are minimal. The intent of the fill is to achieve the design grades with minimum of future settlement as possible, therefore, the type of material utilized will not greatly impact the performance of the cover system. The only requirements for the general fill are that it be placed and compacted to form an unyielding subgrade for construction of the cover system and that it be sufficiently permeable to allow vertical migration of gases generated in the waste. Based on this, almost any type of granular soil could be used. A low plasticity soil could also be used provided that some gravel columns were incorporated into the fill to allow gas to migrate to the gas collection system within the cover section.

Based on the performance requirements and in order to control costs, limited requirements for placing, spreading and compacting this material will be included in the specifications. Currently, it is envisioned that the fill will be obtained from onsite (RFETS) excavations or from nearby off-site sources.

7 2 2 Surface Water Control

Surface storm water runoff and runon will be controlled on the cover and surrounding areas by grading the surface to shed water to the landfill perimeter drainage ditches which will discharge the water into No Name Gulch below the landfill pond embankment. Portions of the landfill cover will drain into the pond, however. Several small seeps from the landfill have occurred in this area. It is expected that these seeps will cease as the landfill is dewatered due to the combined effects of the proposed slurry wall and the landfill cover. The central portion of the landfill will be mounded and sloped approximately 7 percent towards the perimeter. As mentioned above, the minimum post settlement grades are expected to be in the range of 3 to 5 percent.

Existing ditches on the north and south side of the perimeter will be rerouted to accommodate regrading of surface contours in these areas (see Figure 7-2).

During the final design, the volume of runoff from the landfill and runon to the landfill will be determined to size the drainage and diversion ditches around the perimeter of the landfill. The design analyses will be conducted to determine the amount of runoff and runon for a 100-year, 24-hour storm as required by State of Colorado regulations for hazardous waste landfills (6 CCR 1007-3).

7 2 3 Cover Section

As previously discussed in Chapters 5 and 6, the preferred Alternative 7 Single-Barrier FMC with Low Permeability Soil Cover best meets the evaluation criteria considered in the IM/IRA screening process. Major factors such as long term and short term effectiveness and implementability, as well as technical performance, administrative, and regulatory compliance issues were considered in the selection process. In addition to this evaluation, it is also worthwhile to mention that Cover Design Alternative 7 is compatible with the cover elements and functions discussed above. For example, if settlement occurs in the central portion of the landfill, the cover will be generally placed in compression. The physical flexibility and yieldability properties of the soil and geosynthetic material components in this situation will allow the cover to sustain minor displacements without rupturing. Similarly, these materials are flexible when thermal expansion or contraction takes place. The local soils and vegetation used in the vegetative layer, which serve to resist erosion and promote evaporation of infiltrating rain water, will be visually compatible with the surrounding landscape. The cover materials are also amenable to the penetrations made by the gas collection system piping. Geosynthetic boots designed to restrict infiltration around the pipe penetration are commonly used in cover construction.

The various components of preferred FMC with Low Permeability Soil Cover are illustrated in Figure 7-5. The components from top down are the vegetative layer, a

drainage layer, the FMC barrier, a low permeability soil layer, the gas collection layer, and finally, the interim cover or general fill layer which lies directly on the interim cover over the waste. Each of these components plays an important role in the overall hydrologic performance of this cover system.

The top soil component and underlying vegetative layer provides a substrate for vegetation development and evapotranspiration of rain water. Water leaving the system in this manner does not contribute to leachate generation. HELP analyses indicate that 61.7 percent of the storm water that falls onto the surface of the cover is removed from the system through evapotranspiration and 0.2 percent through direct runoff. The majority of the remainder percolates through the soil and geotextile filter fabric into the geonet drainage layer which lies directly on the FMC. The filter fabric keeps the geonet free of silt and enhances flow of water along the geonet ribs and FMC. Another 38.1 percent of the percolating water is removed from the system via the drainage geonet. Of the storm water that originally entered the system, this leaves 0.001 percent which will either be stored in the low permeability soil layer, the interim cover, the waste layer, or flow out of the landfill as leachate. With the construction of the slurry wall functioning to divert upgradient groundwater flow and the cover diverting storm water from the surface, the water levels inside the landfill are expected to fall and eventually the seeps and any discharges to the basal soil formations will be reduced substantially.

7.2.4 Seepage Control

Previous field investigations at the site have documented seeps at the toe of the eastern slope of the OU 7 facility. The planned slurry wall along the north side of the landfill is expected to reduce the amount of groundwater entering the landfill and therefore, may reduce or stop the seeps. However, to accommodate the seep, a blanket or French drain system will be incorporated into the cover section and general fill placement. The drain will cover the seep area and continue to the edge of the landfill cover where it will discharge into the East Landfill Pond.

7.2.5 Gas Control

Gas generation and discharge from the OU 7 facility has been well documented (DOE 1994a). Therefore, the cover is designed to collect and discharge the gases in a safe and controlled manner. The cover section includes a gas collection layer at the base of the cover section directly on top of the waste, interim cover layer or general fill grading layer. The gas is collected in the gas collection layer and conducted into a series of collection pipes which will penetrate through the cover at select locations to vent to the surface.

Based on the gas monitoring that has been completed to date, an assessment of the requirements for permitting the gas discharge was made and is presented in Appendix J. This analysis indicated that permitting the discharge would not be required and that a gas treatment system would not be required.

7.2.6 Ancillary Facilities

A 6-foot-high chain link fence with warning signs which entirely surrounds the landfill will prohibit access by unauthorized personnel. The fence is located outside the limits of the cover and its construction will not impact the cover. Gates will allow access to the cover for maintenance and inspections. In addition, the area will be identified with signs indicating the nature of the facility and warning the public about the dangers of excavations in the area.

7.3 Summary and Conclusions

The conceptual landfill closure design as described above and shown on Figures 7-1 through 7-5, meets the regulatory requirements as outlined in Section 1. Table 7-2 presents a summary of the regulations and the corresponding components of the closure design that address each criteria.

Table 7-1
Summary of EPA Guidance Criteria for Design of
Cover Systems (EPA 1989 and 1991)

Component	Design Criteria
Vegetative Cover	<ol style="list-style-type: none"> 1 Thickness greater than or equal to 2 feet 2 Minimal erosion and or maintenance 3 Vegetative root growth not to extend below 2 feet 4 Final top slope between 3 to 5 percent after settlement or subsidence Slopes greater than 5 percent not to exceed 2.0 tons/acre erosion (USDA Universal Soil Loss Equation) 5 Surface water drainage system capable of conducting run-off across cover without rills and gullies
Drainage Layer	<ol style="list-style-type: none"> 1 Thickness greater than or equal to 1 foot 2 Saturated hydraulic conductivity greater than or equal to 1×10^{-3} cm/sec 3 Bottom slope greater than or equal to 2 percent (after settlement) 4 Overlain by graded granular filter or synthetic filter to prevent clogging 5 Allow lateral flow and discharge of liquids
Barrier Layer - FMC Component	<ol style="list-style-type: none"> 1 Thickness greater than or equal to 20 mil 2 Final upper slope greater than or equal to 2 percent (after settlement) 3 Located wholly below the average depth of frost penetration in the area
Barrier Layer - Soil Component	<ol style="list-style-type: none"> 1 Thickness greater than or equal to 2 feet 2 Saturated hydraulic conductivity less than or equal to 1×10^{-7} cm/sec 3 Installed in 6-inch lifts
The above design components are only recommendations by EPA. Alternative designs can be suggested provided that they result in a comparable performance of the cover system.	

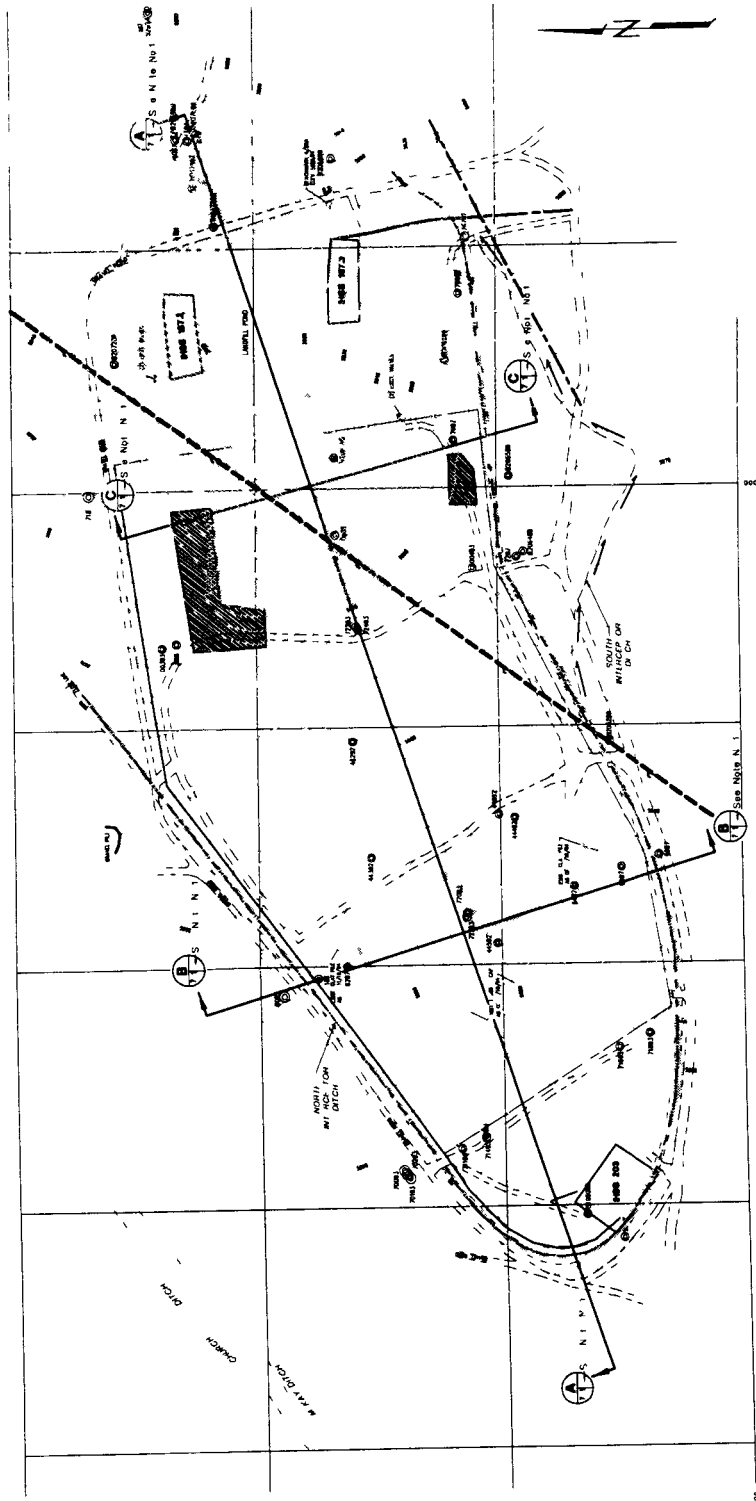
Table 7-2
Design Component Summary

Regulatory Criteria	Design Criteria	Design Component	Discussion
6 CCR 1007-3 CDH			
Minimize fluid migration through the closed landfill	<ol style="list-style-type: none"> 1 Thickness greater than or equal to 2 feet 2 Minimal erosion and or maintenance 3 Vegetative root growth not to extend below 2 feet 4 Final top slope between 3 to 5 percent after settlement or subsidence Slopes greater than 5 percent not to exceed 20 tons/acre erosion (USDA Universal Soil Loss Equation) 5 Surface water drainage system capable of conducting run-off across cover without rills and gullies 	<p>Vegetative Cover</p> <ul style="list-style-type: none"> • 36-in -thick top soil and vegetation • Post settlement slopes 3 - 5 % • Soil type meets erosion requirements • 3 - 5% slopes and vegetation selected to reduce erosion 	
Function with minimum maintenance	<ol style="list-style-type: none"> 1 Thickness greater than or equal to 1 foot 2 Saturated hydraulic conductivity greater than or equal to 1×10^{-3} cm/sec 3 Bottom slope greater than or equal to 2 percent (after settlement) 4 Overlain by graded granular filter or synthetic filter to prevent clogging 5 Allow lateral flow and discharge of liquids 	<p>Drainage Layer</p> <ul style="list-style-type: none"> • Geosynthetic drainage materials will transmit liquids as well as 1 ft soil drainage layer 	

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Regulatory Criteria	Design Criteria	Design Component	Discussion
Promote drainage and minimize erosion or abrasion of the cover	<ol style="list-style-type: none"> 1 Thickness greater than or equal to 20 mil 2 Final upper slope greater than or equal to 2 percent (after settlement) 3 Located wholly below the average depth of frost penetration in the area 	Barrier Layer - FMC Component <ul style="list-style-type: none"> • FMC will be greater than 20 mil • Located below frost depth of 36 in 	<ul style="list-style-type: none"> • Final design, decision PVC vs HDPE, thickness
Accommodate settling so that the integrity of the cover is maintained	<ol style="list-style-type: none"> 1 Thickness greater than or equal to 2 feet 	Surface slopes at 7% will sustain expected settlement	
Have a permeability less than or equal to the permeability of any bottom liner system or material subsoils present	<ol style="list-style-type: none"> 1 Saturated hydraulic conductivity less than or equal to 1×10^{-7} cm/sec 2 Installed in 6-inch lifts 	Barrier Layer - Soil Component <ul style="list-style-type: none"> • Thickness 4 ft • Permeability of FMC at 1×10^{-13} cm/sec 	In final specifications, CQA Plan
Title 40 - Code of Federal Regulations (40 CFR), Part 264			
U S EPA Technical Guidance Document Final Covers on Hazardous Waste Surface Impoundments, EPA/530-SW-89-047, July 1989	Similar to State regulations above		

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SCALE
0 200 400
CONTOUR INTERVAL 100'

LEGEND

- FAULT
- - - DITCH
- ROADS
- TRANSMISSION LINE
- ▨ ASBESTOS AREA (APPROXIMATE)
- 71683③ EXISTING WELL OR OR EXPLORATION BOREHOLE

NOTES

- 1) REFERENCED ON DRAWINGS 13 AND 14
- 2) BASE TOPOGRAPHY AND FEATURES PROVIDED BY EG & G

DRAWING NO. WHERE DETAIL SECTION IS REFERENCED
DETAIL/SECTION NUMBER
DRAWING NO. WHERE DETAIL SECTION IS SHOWN

U.S. Department of Energy
Rocky Flats Environmental Technology Site Golden Colorado

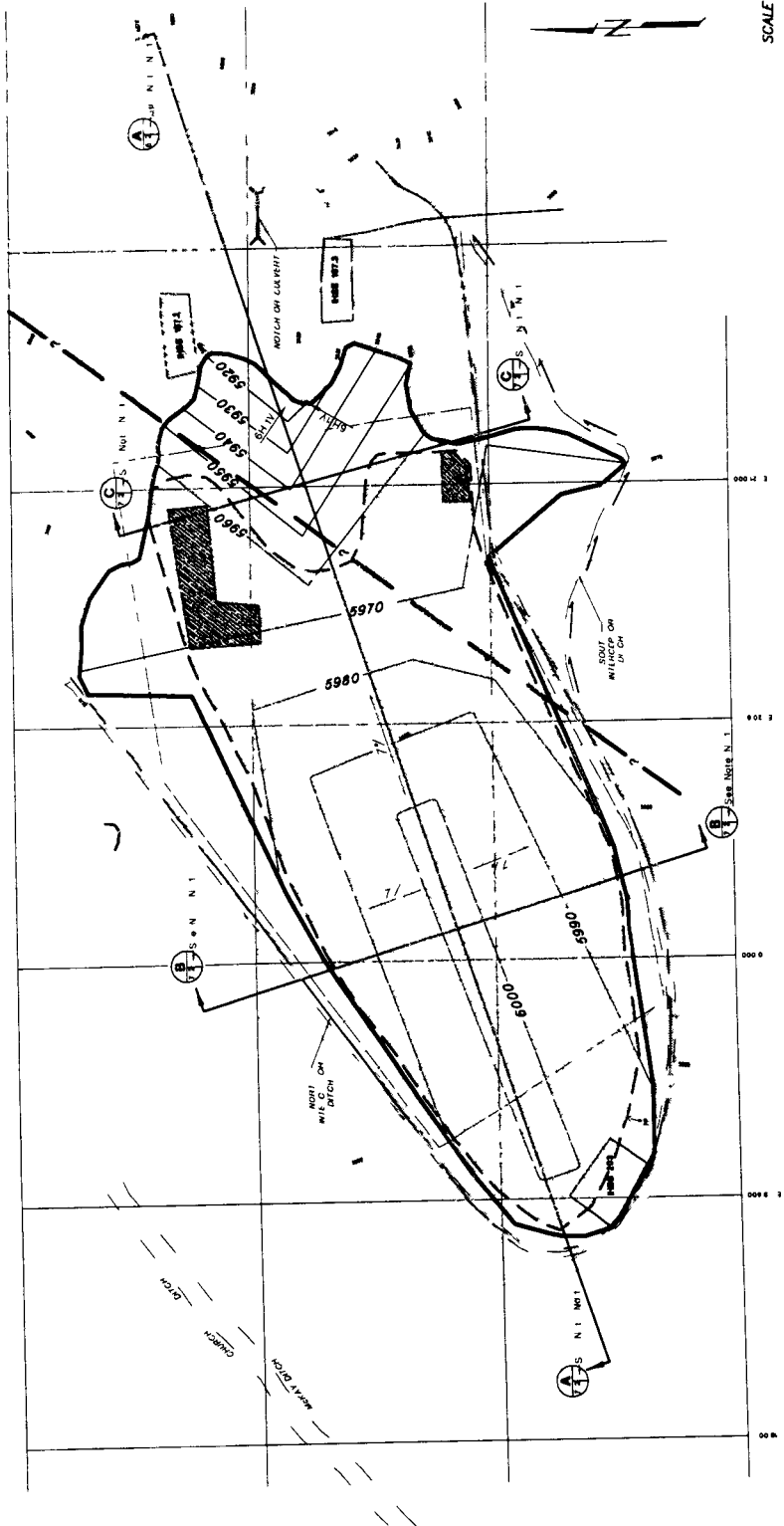
Existing Topography and Surface Features

Phase 1 IM/IRA Operable Unit No 7

Date July 1995

Figure 7-1

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LEGEND

- FAULT
- DITCH
- CONCEPTUAL GRADING PLAN CONTOURS
- EDGE OF REGRADE AREA
- EDGE OF LANDFILL
- ASBESTOS AREA
- COVER AREA

SUBSITE VOLUME TABLE UNADJUSTED

SUBSITE	STRUTUM	SURF 1	SURF 2	CUT YARDS	FILL YARDS	NET YARDS
01	CAP 1	NI W	NI API	1992	237,194	234,191 (1)

DETAIL/SECTION NUMBER
DRAWING N. WHERE DETAIL/SECTION IS REFERENCED

NOTES:
1) REFERENCED ON DRAWINGS 1, 3 AND 4
2) BASE TOPOGRAPHY AND FEATURES PROVIDED BY EG & G

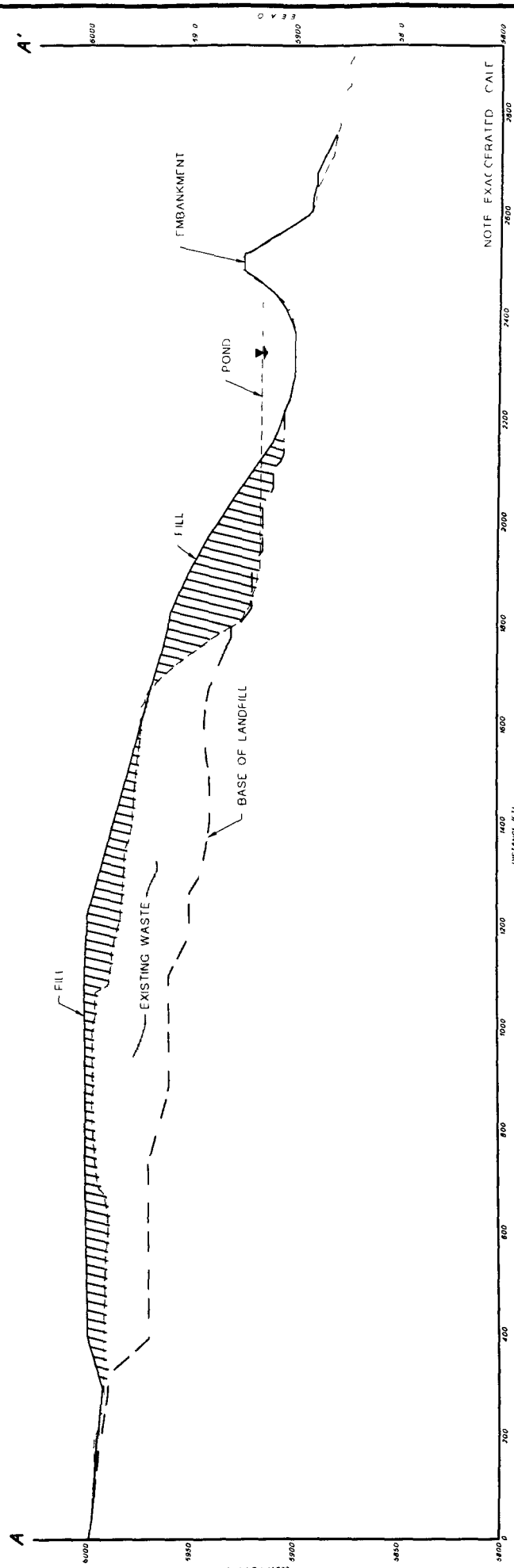
U.S. Department of Energy
Rocky Flats Environmental Technology Site Golden Colorado

Proposed Conceptual Grading Plan, Extent of Cover, and Surface Water Control Plan

Phase I IM/IRA Operable Unit No. 7

Date July 1995 Figure 7-2

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See Note No 1
CROSS-SECTION A-A'

HORIZONTAL SCALE
 0 100 200
 VERTICAL SCALE
 0 25 50

LEGEND

- CURRENT SURFACE
- BASE OF LANDFILL SURFACE
- PROPOSED CONCEPTUAL GRADING PLAN
- ▨ FILL
- ▨ EXISTING LANDFILL

NOTE
 1) REFERENCED ON DRAWING 7-1 AND 7-2

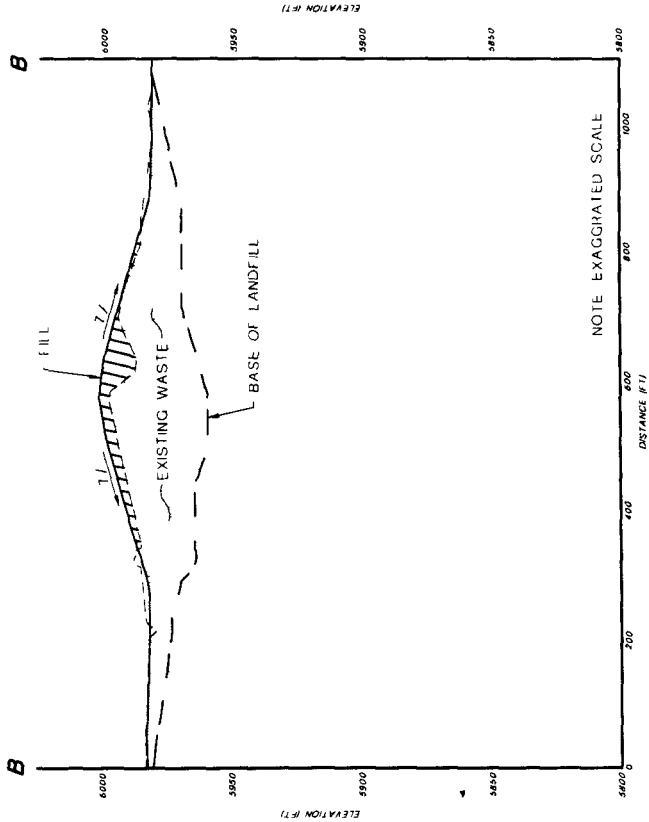
DRAWING NO. WHERE
 THIS SECTION
 IS REFERENCED
 IS SHOWN
 DETAIL/SECTION
 NUMBER
 A-A'

U.S. Department of Energy
 Rocky Flats Environmental Technology Site
 Golden, Colorado

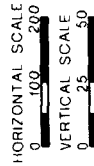
Landfill Cover Cross Section A-A'

Phase I IM/IRA
 July 1995
 Operable Unit No 7
 Figure 7-3

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See Note No 1 **CROSS-SECTION B-B'**

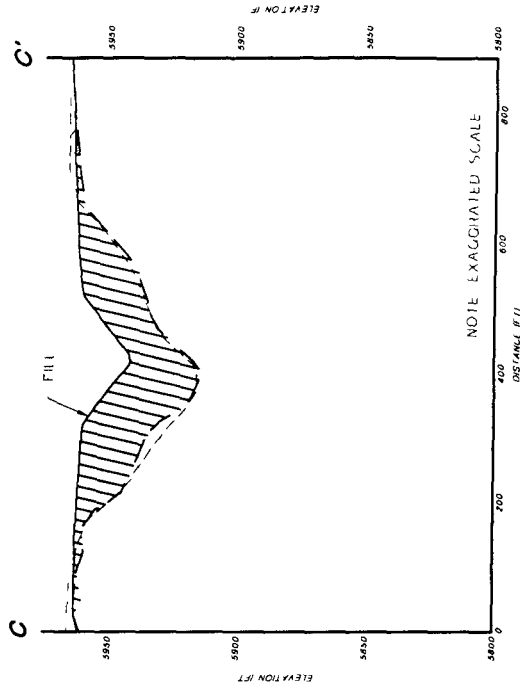


LEGEND

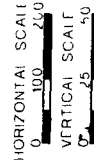
- CURRENT SURFACE
- BASE OF LANDFILL SURFACE
- PROPOSED CONCEPTUAL GRADING PLAN
- ▨ FILL
- ▨ EXISTING LANDFILL

NOTE
1) REFERENCED ON DRAWING 7-1 AND 7-2

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See Note No 1 **CROSS-SECTION C-C'**



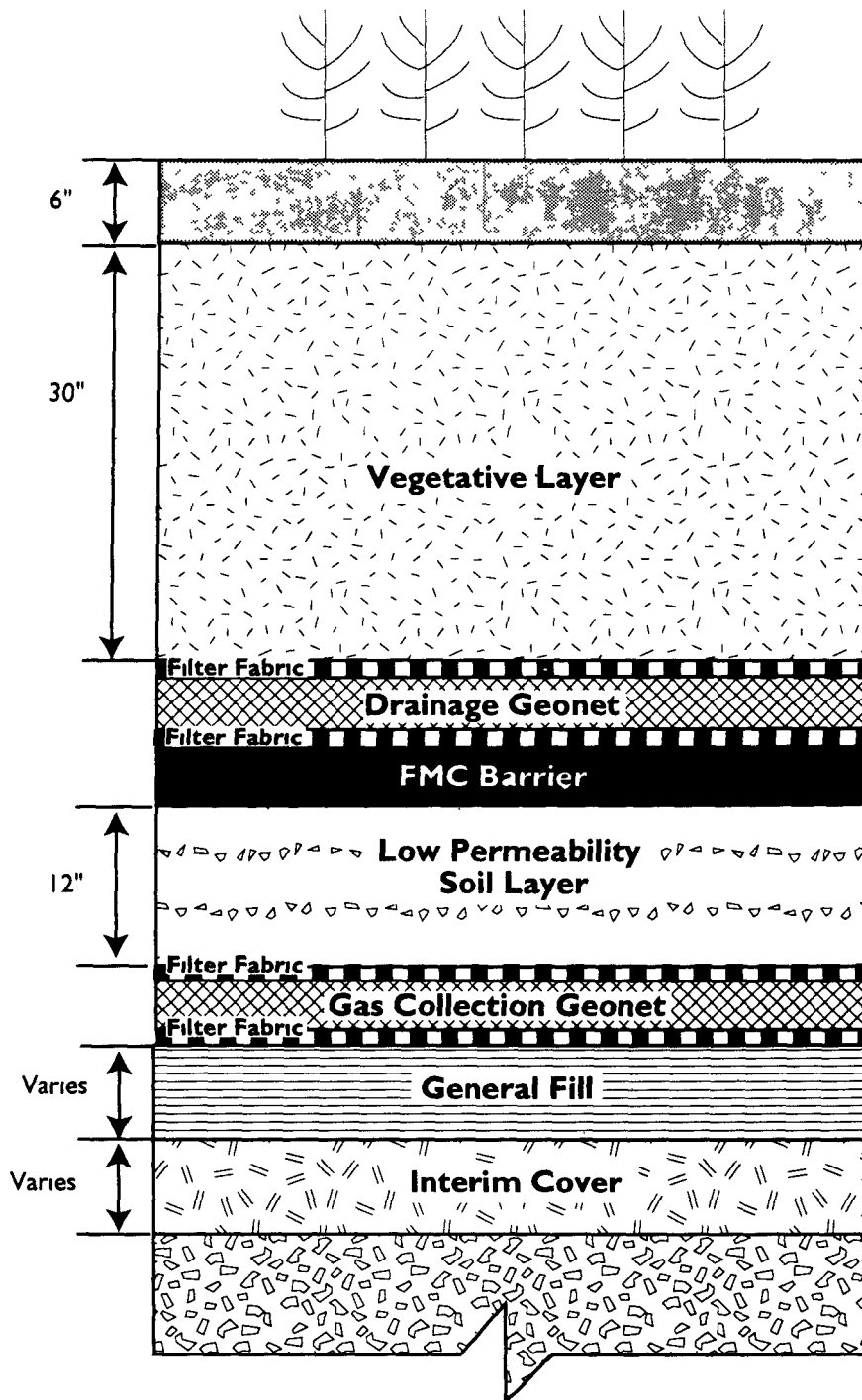
U.S. Department of Energy
Rocky Flats Environmental Technology Site Golden Colorado

Landfill Cover Cross Section B-B' & C-C'

Phase I IM/IRA Operable Unit No 7

July 1995

Figure 7 4



U S Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

**Proposed Alternative 7: Single-Barrier
FMC & Low Permeability
Soil Cover Cross Section**

Phase I IM/IRA

Operable Unit No 7

Date July 1995

Figure 7-5

8. Closure and Post-Closure Plans

8.1 Closure Plan

This Closure Plan addresses the requirements for closure outlined in 6 CCR 1007-3 Section 265 111. The plan describes the plans and procedures that will be followed during closure, the maximum inventory, decontamination of equipment, other closure activities, and the final closure schedule.

8.1.1 Description of Landfill Closure

The Present Landfill (IHSS 114) is an operating landfill that covers an area of approximately 27 acres at RFETS. A description of RFETS, OU 7, and the hydrologic conditions is located in Sections 1 and 2. The landfill will be closed in accordance with 6 CCR 1007-3 Section 265 111 "in a manner that

- Minimizes the need for further maintenance
- Controls, minimizes, or eliminates, the extent necessary to protect human health and the environment, post closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere, and
- Complies with the closure requirements" of Subpart G and 6 CCR 1007-3 Section 265 310

Landfill closure consists of capping the landfill, IHSS 203 and the asbestos disposal areas with a RCRA Subtitle C equivalent cover. As discussed in Section 5, the final cover is designed to meet the requirements of 6 CCR 1007-3 Section 265 310.

- Provide long-term minimization of migration of liquids through the closed landfill
- Function with minimum maintenance,
- Promote drainage and minimize erosion of abrasion of the cover,
- Accommodate settling and subsidence so that the cover's integrity is maintained and
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoil present

The proposed action is a composite barrier landfill cap consisting of a FMC overlying a layer of low permeability soil as discussed in Section 7.

8 1 2 Maximum Extent of Operations

Operation of the Present Landfill began on August 14, 1968, and is expected to continue until the opening of the new landfill in January 1997. The waste disposal procedures currently used at the landfill have not significantly changed since the landfill went into operation in 1968 (DOE 1994a). Waste is delivered to the landfill three days a week and waste is spread across the work area. After radiation monitoring is completed, the waste is compacted and buried with six inches of clean fill from onsite stockpiles. A lift is completed by the addition of a 3-foot-thick layer of compacted soil. The active portion of the landfill and the maximum extent of waste is shown in Figure 5-1.

8 1 3 Management of Maximum Inventory

The total volume of material in the landfill is approximately 415,000 CY. Assuming that approximately 30 percent of the total material is soil cover, the volume of the waste is approximately 291,000 CY. As discussed in Section 2, disposal of hazardous waste in the landfill was prohibited after November 1986. It is estimated that the landfill contains approximately 80,000 CY of hazardous waste.

The landfill is presently receiving approximately 12,000 CY per year of municipal waste and has a total capacity of ? CY. Based on the present yearly disposal rate, the landfill is expected to have 540,000 CY of waste and fill at closure in 1997 (DOE 1994a).

All wastes will remain within the landfill and will be covered. A detailed description of the cover, conceptual design drawings, and installation procedures are included in Section 7. Drawings and specifications will be submitted as the Title II design. Waste from closure activities will be consolidated beneath the final cover.

The current filling plan for the OU 7 landfill envisioned mounding in the center of the landfill to provide surface water drainage to the perimeter of the waste before closure. However, given the current and projected waste inflow rates, the waste will not reach these design grades before closure of the facility in January 1997. Therefore, a large volume of general fill will be required to achieve grades that will drain surface water off of the facility and meet regulatory criteria.

Figure 7-2 shows the conceptual grading plan for OU 7 and Figures 7-3 and 7-4 indicate cross-sections through the OU 7 facility and indicate the extent of the fill areas. The grading plan incorporates 7 percent surface grade across the majority of the landfill that drain to the perimeter. Along the east slope of the landfill, the grade steepens to approximately 6H 1V (9.5 degrees). Based on this plan, a total of approximately 225,000 cubic yards of fill material will be required to achieve the design grades.

The minimum surface grade is established based on the regulatory criteria of 3 to 5 percent minimum surface grades and the expected amount of surface settlement from placement of the general fill (to achieve design grades) and decomposition of the waste. Settlement of the OU 7 waste and fill materials was evaluated and although settlements will occur, they are expected to be relatively minor and should not affect surface drainage patterns causing abnormal erosion of the vegetative cover surface.

Settlements at various representative points on the landfill surface were estimated using a simple percent of thickness assessment, Sowers Method, Gibson and Lo Method, and power creep law. Details of the settlement analysis calculations are presented in Appendix 7-F. These methods yielded maximum settlements ranging from 2.9 to 5.5 feet in areas where the waste fill is thickest. The change in surface elevations resulting from these settlements was computed and the resulting surface slopes remained within the recommended 3 to 5 percent range.

8.1.4 Equipment Decontamination

Equipment used during the landfill closure will be decontaminated at the main decontamination facility located adjacent to and south of the 903 Pad. Decontamination will be conducted in accordance with EMD Operating Procedures, Field Operations FO 4, Heavy Equipment Decontamination (EG&G 1995d), and FO 12, Decontamination Facility Operations (EG&G 1992e).

8.1.5 Groundwater Monitoring

During the final closure period, groundwater will be monitored in compliance with 6 CCR 1007-3 Subpart F. Groundwater monitoring wells are shown on Figure 8-1. Well 50094 has been selected to monitor upgradient groundwater in order to provide representative background data. Wells 52894, 53094, and 53194 will be used to monitor groundwater downgradient of the landfill. During the closure period the wells will be monitored in accordance with EMD Operating Procedures, Groundwater GW 06, Groundwater Sampling (EG&G 1992b) based on the following schedule:

**Table 8-1
Post-Closure Maintenance and Monitoring Schedule**

Item	Frequency
Final cover inspection	biannual
Final cover survey	annual
Drainage ditch cleanout	annual
Fence inspection	annual
Gas monitoring	quarterly

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Item	Frequency
Groundwater monitoring	
Indicator parameters	annual
Contamination parameters	biannual

The wells will be inspected concurrently with biannual sampling, and maintained as necessary

8 1 6 Ancillary Closure Activities

The landfill cap will be monitored for settlement. The elevations of settlement markers will be surveyed annually and evaluated to determine surface settlement.

Gas generation and discharge from the OU 7 facility has been well documented (DOE 1994a). Therefore, the cover must be designed to collect and discharge the gases in a safe and controlled manner. The cover section, as previously described, includes a gas collection layer at the base of the cover section (directly on top of the waste, intermediate cover layer or general fill grading layer). The gas will be collected in the gas collection layer (which will blanket the landfill) and conducted into a series of collection pipes which will penetrate through the cover at select locations to vent to the surface.

Based on the gas monitoring that has been completed to date, an assessment of the requirements for permitting the gas discharge was made and is presented in Appendix J. This analysis indicated that permitting the discharge would not be required and that a gas treatment system would not be required.

Surface storm water runoff and runoff will be controlled on the cover and surrounding areas by grading the surface to shed water to the landfill perimeter drainage ditches which will discharge the water into the No Name Gulch below the landfill pond embankment. Portions of the landfill cover will drain into the pond, however. Several small seeps from the landfill have occurred in this area. It is expected that these seeps will cease as the landfill is dewatered due to the combined effects of the proposed slurry wall and the landfill cover. The central portion of the landfill will be mounded and sloped approximately 7 percent towards the perimeter. As mentioned above, the minimum post settlement grades are expected to be in the range of 3 to 5 percent.

Existing ditches on the north and south side of the perimeter will be rerouted to accommodate regrading of surface contours in these areas (see Figure 7.2).

During the final design, the volume of runoff from the landfill and runoff to the landfill will be determined to size the drainage and diversion ditches around the perimeter of

the landfill. The design analyses will be conducted to determine the amount of runoff and runoff for a 100-year, 24-hour storm as required by State of Colorado regulations for hazardous waste landfills (6 CCR 1007-3)

A 6-foot-high chain link fence with warning signs which entirely surrounds the landfill will prohibit access by unauthorized personnel. The fence will be located outside the limits of the cover and its construction will not impact the cover. Various gates will be constructed in the perimeter fence to allow access to the cover for maintenance and inspections. In addition, to a perimeter fence the area will be identified with various signs indicating the nature of the facility and warning the public about the dangers of excavations in the area. Fences will be inspected annually and maintained as necessary.

8.1.7 Closure Certification

Within 60 days of completing final closure, DOE will submit to CDPHE certification that the landfill has been closed according to the approved Closure Plan. The certification will be signed by DOE and an independent registered professional engineer.

8.1.8 Survey Plat

No later than the submission of closure certification, DOE will submit a survey plat prepared and certified by a professional land surveyor to the county clerk's office and CDPHE. The plat filed with the local zoning authority will have a note which "states the owner's or operator's obligation to restrict disturbance of the hazardous waste disposal unit in accordance with Subpart G".

Permanently surveyed benchmarks that will be used as a basis for the survey plat are shown in Figure 8-1.

8.1.9 Deed Notation

DOE will record a notation to the property deed at the county clerk's office noting that the property was used to manage hazardous wastes and its use is restricted. A copy of the notation and certification will be submitted to CDPHE.

8.1.10 Final Closure Schedule

The schedule for landfill closure was developed in accordance with the RCRA Guidance Manual for Subpart G Closure and Post-Closure Care Standards (EPA 1987). It was assumed that the new landfill will be operational in April 1997.

Table 8-2
Closure Timeline

Activity	Date
Notification Of Closure	March 1997
Receipt Of Final Volume	April 1997
Completion Of Closure Activities	October 1997
Submittal Of Survey Plat	December 1997
Submittal Of Certification Of Closure	December 1997
Submittal Of Record Of Wastes	February 1998
Submittal Of Deed Notation	February 1998

8.2 Post-Closure Plan

This Post-Closure Plan addresses the requirements for post-closure care outlined in 6 CCR 1007-3 Section 265 117-120. The plan describes the monitoring and maintenance that will be followed during the 30 year post-closure period.

8.2.1 Post-Closure Permit

For landfill facilities, a post-closure permit is required under 40 CFR 270.1(c). The purpose of the permit is to detail the requirements of post-closure care. Pertinent information to be included in the application as described in 40 CFR 270.13 and 270.14, should include, at a minimum, the following information: a copy of post-closure inspection schedule, post-closure plan, and notation to the property deed, floodplain information, applicable groundwater and landfill gas monitoring data and information demonstrating compliance or corrective action, information on solid waste management units and corrective action for releases from those units, and information on the potential for the public to be exposed to hazardous wastes released from the landfill. The permit will be obtained after closure activities have been concluded.

8.2.2 Maintenance

DOE will conduct routine biannual inspections of the final cover, surface water interceptor ditch, surveyed benchmarks, groundwater monitoring system, gas monitoring system and the site fencing.

DOE will maintain the integrity and effectiveness of the final cover through fertilizing, reseeding of bald spots, replacing soil lost to erosion, maintaining drainage channels and controlling rodents as necessary.

DOE will maintain the groundwater monitoring system and gas monitoring system by repairing any defects noted during the inspections DOE will perform all regular maintenance required by equipment manufacturers

DOE will inspect the security fence, warning signs and surveyed benchmarks annually and maintain them as needed

A summary of maintenance activities and frequencies is included in Table 8-1

8 2 3 Monitoring

As described in the Closure Plan, the groundwater monitoring system consists of Well 50094 upgradient of the landfill and Wells 52894, 52994, and 53094 downgradient of the landfill Locations of the groundwater monitoring wells are shown in Figure 8-1 DOE will monitor the wells biannually [EPA, Solid Waste Disposal Facility Criteria, Section 6 6 1(a)(3)] following the sampling procedures outlined in 6 CCR 1007-3 Subpart F 265 91 Two types of data are to be collected groundwater quality data and contamination data Groundwater quality parameters, sampled and analyzed annually, include chloride, iron, manganese, phenols, sodium and sulfate Groundwater contamination parameters, requiring 4 replicates, are to be sampled and analyzed semi-annually include pH, specific conductance, TOC, and TOX

Landfill gas monitoring will be performed quarterly using the gas vents installed within the final cover system The gas vents are integrally connected to the gas collection layer that will vent the landfill gas and allow gas monitoring Gas monitoring will be performed manually at each gas vent location using a portable combustible gas indicator (CGI) and a photoionization detector (PID) The CGI will be used to monitor the landfill gas in the vents for combustible gases and oxygen levels, and the PID will be used to monitor the vented gas for volatile organic constituents

A summary of monitoring activities and frequencies is included in Table 8-1

8 2 4 Contact Person

[name, phone, address]

8 2 5 Closure Certification

Within 60 days of completing the post-closure care period, DOE will submit to CDPHE a certification that the post-closure care has been completed according to the approved Post-Closure Plan The certification will be signed by DOE and an independent registered Professional Engineer

8 2 6 Financial Assurance and Cost Estimates

State and Federal governments are exempt from the financial assurance requirements of Subpart H of 40 CFR 265 140 (c)

The estimated cost for the closure of the landfill is \$8,871,600 The total present worth annual and capital periodic operation and maintenance costs totals \$1,014,700 The detailed cost estimate is in Appendix H

9. Environmental Assessment

The proposed IM/IRA for landfill closure would be a final action and would have some site impacts and some impacts to the surrounding area, compared to the impacts expected from the no-action alternative. The potential environmental and human health effects resulting from the proposed IM/IRA activities are discussed in this section. Human health exposures during construction of the final remedy, post-closure maintenance and monitoring activities, and exposures resulting from possible accidents are analyzed for risks to workers involved with IM/IRA activities, to other workers at Rocky Flats, and to the public. Environmental impacts to ecology, air quality, surface water quality, and groundwater quality are analyzed in detail. The commitment of material and people and potential impacts to transportation and other short-term, long-term, and cumulative impacts are also analyzed and discussed in detail.

As part of the routine maintenance program, a slurry wall will be constructed along the north side of the landfill. This slurry wall will divert upgradient groundwater that is currently flowing under or through the existing groundwater intercept system, causing saturation of the landfill mass around the landfill. An accelerated action consisting of a passive leachate collection/treatment system will be implemented under the Modified Leachate Collection and Treatment PAM (DOE 1995a). Actions proposed in support of final closure of OU 7 consist of an interim action to be implemented under this landfill closure IM/IRA. The proposed IM/IRA will address the containment of the landfill mass and the control or collection and treatment of any landfill off-gases. A cover will be constructed to contain landfill waste, soils at IHSS 203, soils and sludges at IHSS 166 1, and the asbestos disposal areas. A passive gas-venting system, consisting of a gravel or geocomposite filter layer placed directly over the existing interim soil cover, will collect and vent gases at discharge points. The existing surface water diversion ditch will be used as is or modified to divert surface water around the landfill. Approximately 50 percent of the East Landfill Pond and wetlands will remain in place.

The proposed construction activities of the landfill closure IM/IRA will include placement of general fill and regrading to achieve adequate surface drainage, placement of the engineered cover system, placement of the final vegetative cover, and upgrading the runoff/runon diversion ditch system. A post-closure landfill maintenance and monitoring program will be performed for 30 years after landfill closure. The post-closure monitoring/maintenance program will generally include groundwater sampling and analysis, facility inspections to monitor settlement, erosional distress, cover integrity, and diversion ditches, and any maintenance necessary to correct deficiencies observed during monitoring.

The intent of the proposed action is to minimize potential impacts from the landfill by encapsulating the waste and contaminated media. The installation of the engineered cover system would not disturb or contact contaminated media. Minor potential impacts or risks associated with the construction activities of the proposed IM/IRA are anticipated. However, these risks would be offset by the resulting enhancements of environmental quality at the site.

This section presents the environmental assessment for the proposed final action and is the functional equivalent of an environmental impact statement (EIS).

9.1 Human Health Screening Level Risk Assessment

The purpose of this screening level risk assessment (SLRA) is to identify and qualitatively examine the potential risks to human receptors associated with the installation and maintenance of the engineered cover under the IM/IRA at the OU 7 landfill. This IM/IRA is expected to be the final action at the OU 7 landfill. This assessment includes:

- identification of potential contaminants of concern or activities of concern
- characterization of potential exposure
- estimation of potential magnitude of risk
- identification of uncertainties associated with the assessment

Assessment of potential risks associated with the IM/IRA activities will allow risk managers to ensure that measures are taken to mitigate any significant risks that are identified. This SLRA does not examine risks associated with leaving landfill contents in place, nor does it examine the individual risks to receptors following interim measures. Only risks associated with the process of implementing interim measures are evaluated.

9.1.1 Identification of Potential Contaminants of Concern or Activities of Concern

For this SLRA, construction activities involved with the IM/IRA may be summarized as:

- construction of an unpaved haul road between Western Aggregates, Inc. and the OU 7 landfill
- transportation of the fill/cover material on the haul road
- placement of the fill and engineered cover at the landfill

Post-construction activities will include monitoring and maintenance of the cover. The landfill contents are covered with a daily soil cover, so the landfill contents will be

covered before IM/IRA construction activities begin. No construction activities are anticipated that will require intrusion into the landfill contents (including asbestos burial areas), into the landfill leachate, into adjacent surface water or into groundwater downgradient from the landfill. In the event that intrusion into these areas becomes likely, worker safety and any necessary precautions will be addressed by the site-specific health and safety plan. Long-term risks evaluated as part of the presumptive remedy process are discussed in Section 3.3.

Methane and carbon dioxide gases are generated by biodegradation of the landfill contents, however, as they are emitted from the landfill, these simple asphyxiants are expected to be greatly diluted and dispersed by the wind. Because they are not expected to displace the oxygen present in the air, they pose negligible risk at the low concentrations anticipated in the breathing zone. Therefore, the identification of potential contaminants of concern (PCOC) will focus on the material used for the fill and engineered cover.

The material used to construct the haul road is expected to be road-base aggregate, while materials for the fill and engineered cover include clay, sand, gravel, and topsoil, with a vegetative cover developed after construction. During earth moving activities, there is the potential to generate dust. Because the earthen materials that will be used are uncontaminated materials, the potential concern with dust emissions is the nuisance associated with it.

An occupational activity of concern is the operation of heavy equipment and transporting the road-base aggregate and fill/cover material. However, these activities are addressed under routine occupational standards designed to reduce risks, and are typically incorporated into the health and safety plan.

In summary, construction activities will not involve intrusion into the landfill contents, and the fill and cover materials used will be uncontaminated. Therefore, the PCOC identified for the OU 7 IM/IRA is nuisance dust.

9.1.2 Characterization of Exposure

The objective of characterizing exposure is to estimate the type and potential magnitude of exposures to the PCOCs that are present at the site or that may migrate from the site. The results of the exposure assessment will be combined with guidelines for nuisance dust to characterize potential risks.

The exposure assessment consists of the following components:

- Characterize potentially exposed human populations (i.e., receptors)
- Identify exposure pathways
- Qualitatively determine the extent of exposure

9 1 2 1 *Potentially Exposed Populations and Exposure Pathways*

Potential scenarios and exposure pathways are identified using planned land uses both on- and off-site. The planned on-site use associated with OU 7 is capping, monitoring, and maintaining the engineered cover of the closed landfill. These activities will involve construction workers for capping and maintaining, and field technicians for sampling. Because the potential for dust generation is higher during the earth-moving activities, the exposure to dust is greater for construction workers at OU 7 than for technicians.

Off-site land uses are considered according to current and future uses, which are identified through county zoning maps and observation or projected based on growth patterns and community development plans. Current land uses around Rocky Flats include open space, limited agricultural, commercial/industrial, and residential. Although there is currently no residential use adjacent to Rocky Flats, a hypothetical residential receptor is conservatively assumed for this screening level analysis.

In summary, two potentially exposed human receptors were selected for pathway analysis in this SLRA:

- On-site worker
- Off-site resident

9 1 2 2 *Exposure Pathway Analysis*

An exposure pathway describes a specific environmental pathway by which a receptor can be exposed to PCOCs that are present at or migrating from the site. Five elements comprise an exposure pathway. These elements, shown below, are identified to determine potential exposure pathways at the site:

1. A source,
2. A mechanism of release to the environment,
3. An environmental transport medium (e.g., air, groundwater) for the released constituent,
4. A point of contact between the contaminated medium and the receptor (i.e., the exposure point), and
5. An exposure route (e.g., inhalation of dust) at the exposure point.

All five of these elements must be present for an exposure pathway to be potentially complete.

An exposure route is the pathway through which a contaminant enters or impacts an organism. There are four basic human exposure routes:

- 1 Dermal absorption
- 2 Inhalation
- 3 Ingestion
- 4 External irradiation if radionuclides are present

Potential exposure pathways during implementation of interim measures at OU 7 include inhalation of airborne particulates, soil ingestion, and dermal contact with soil. Because no chemicals are present in the earthen fill and cover materials, no impacts are expected from inadvertent ingestion of soil or from absorption through the skin. The inhalation of nuisance dust is generally unpleasant, but is not expected to have any impact except to individuals that may have severe pre-existing respiratory problems. Therefore, the pathway that will be qualitatively evaluated for the on-site worker and hypothetical off-site receptor is inhalation of nuisance dust.

9.1.3 Potential Magnitude of Exposure and Risk

The potential magnitude of exposure and risk to nuisance dust is dependent upon the emission rates and airborne concentrations. These emission rates and airborne concentrations at the Rocky Flats property boundary are evaluated in Section 9.3, Impacts to Air Quality.

No adverse health impacts are anticipated for the off-site residents or the construction workers. As presented in Section 9.3.2, it is unlikely that air quality standards for respirable dust will be exceeded at the Rocky Flats property boundary. The total sampled particulates concentration in the work area will be controlled through the application of water by a truck such that the occupational limit will not be exceeded. A typical occupational exposure limit for nuisance dust is 10 mg/m³, a level under which it is believed that nearly all workers can be repeatedly exposed day after day without adverse health effects.

Occupational risks associated with the operation of heavy equipment and transporting the road-base aggregate and fill/cover material are expected to be low, and are controlled through occupational regulations or standards. Furthermore, transportation associated with OU 7 will occur on private roads and at lower speeds than are associated with most vehicle accident data. Therefore, these risks are not addressed quantitatively.

9.1.4 Identification of Uncertainty

The uncertainty analysis characterizes the uncertainty associated with each step of the process of assessing risk. These uncertainties are driven by uncertainty in assumptions.

of work activities, identification of PCOCs, estimation of emission rates, the screening level transport model used to estimate concentrations at receptor locations, and assumed receptor locations. The uncertainties associated with this SLRA are summarized in Table 9-1.

Of the uncertainties identified, a key assumption is that there will be no intrusion into the landfill contents as part of the IM/IRA. This includes assuming there will be no intrusion into asbestos burial areas, into the landfill leachate, into adjacent surface water or pond sediments, or into groundwater downgradient from the landfill. In the event that intrusion into these areas becomes likely, worker safety and any necessary precautions will be addressed by the site-specific health and safety plan. The health and safety plan will discuss potential hazards and locations, entry and exit requirements for controlled areas, use of monitoring equipment, use of PPE such as protective clothing and respirators, and emergency response. Occupational risk is expected to be maintained well within standards under these controls.

9.2 Ecological Risk

Construction of the proposed IM/IRA would require soil materials obtained from offsite commercial operations. The excavation of borrow materials may have potential impacts to wildlife and vegetation habitats and potential impacts to possible nearby wetlands/floodplains. These potential impacts are considered in operational permits issued for these facilities by the State of Colorado and local county governments.

The following subsections describe potential ecological impacts to the landfill site due to construction activities associated with the proposed IM/IRA.

9.2.1 Wildlife and Vegetation

Short-Term (Construction Period) Impacts

Some construction activities of the IM/IRA would have impacts to the wildlife habitats within the area of the proposed landfill resurfacing and surrounding areas. No unique or important habitat features would be significantly affected by construction activities. However, temporary loss of mid-grass prairie wildlife habitat is expected because of the surface disturbance (stripping of vegetation) and construction activities (equipment traffic, human activities, etc.). The total area of disturbed vegetation would be approximately 39 acres, including the area of the landfill resurfacing (28 acres), borrow material haul roads (9 acres), and miscellaneous construction activities (2 acres). The existing minimal vegetation on the surface of the landfill is considered a minor wildlife habitat and would be significantly enhanced by the revegetation plan proposed as part of this IM/IRA. Temporary loss of mid-grass prairie wildlife habitat would be expected at the offsite material borrow source. In addition, noxious weeds

could be introduced during revegetation establishment and would be controlled until adequate native vegetation could be established

Temporary loss of habitat may cause direct mortality to small and less mobile animals such as rodents and reptiles resident in the area (see Appendix D, Screening-Level Ecological Risk Assessment). Indirect mortality may occur due to displacement and loss of habitat capacity of larger or more mobile animals such as birds and mule deer and may occur from loss of habitat effectiveness in undisturbed areas next to the construction activities.

Increased equipment and human activities associated with construction would inevitably result in increased noise levels and vehicle traffic. These activities would probably have the least disturbance to wildlife since surrounding areas are already in industrial use and wildlife is habituated. Habitat loss is expected to be temporary and would continue only until adequate revegetation is established. With the use of straw-mulch, adequately spaced silt fences and other appropriate measures, the final vegetative cover would be established within two to three years.

Long-Term Impacts

Construction of the East Landfill Pond to control landfill leachate has created persistent wetlands and aquatic habitats that are small but important components of dry environments such as Rocky Flats. As a result, species drawn to the aquatic resources around the East Landfill Pond would potentially be exposed to contaminants existing in pond water and sediments. Contaminant migration from the landfill would be minimized after the engineered cover is in place. A screening-level ecological risk assessment was performed for OU 7 to provide baseline information of the potential ecotoxicity and ecological risk of PCOCs in seep water and pond water and sediments in the East Landfill Pond (Appendix D, Screening-Level Ecological Risk Assessment).

Leaving approximately half of the East Landfill Pond intact would result in little risk of wildlife exposure to PCOCs in pond water and sediments.

Risks to aquatic life in the pond appear to be minimal. Results of the literature-based toxicity screen and laboratory toxicity testing indicate that pond water represents negligible risk to aquatic life. Based on preliminary risk calculations, risk of toxicity to sediment-associated organisms appears to be high, but results of site-specific surface water and sediment toxicity tests indicate no toxicity.

Low potential toxicity to mammalian and avian wildlife was also observed; seep water was a main contributor to overall risk for mallards and raccoons. However, the seep would be eliminated as an exposure point if the proposed remedy is implemented (see Appendix D).

Preliminary Hazard Quotient (HQ) estimates indicate that sediments may present a risk to raccoons, coyotes, and Preble's Meadow Jumping Mice (see Appendix D). The primary risks to raccoons, coyotes, and Preble's Meadow Jumping Mice would be from naturally occurring metals concentrations in the sediment, but the relatively low HQ values for exposure to the metals suggest low potential toxicity.

Pond water risks to wildlife appear to be limited to exposure of mallards and other waterfowl to bis(2-ethylexyl)phthalate and di-n-butylphthalate. HQ values suggest moderate risk of exceeding NOAELs (no observed adverse effects levels) for individual birds if the birds spend all of their time at the East Landfill Pond and if phthalate concentrations remain constant (see Appendix D).

Sensitive Habitats and Endangered Species

Wetlands have been designated along the shoreline of the East Landfill Pond by the U.S. Army Corps of Engineers (COE 1994). The drainage is also potential habitat for Preble's Meadow Jumping Mouse. The Preble's Meadow Jumping Mouse has been petitioned for listing as a threatened or endangered species pursuant to the Endangered Species Act. The Meadow Jumping Mouse currently receives protection as a non-game species under the Colorado non-game, Endangered, or Threatened Species Conservation Act. The Preble's Meadow Jumping Mouse is a subspecies of the meadow jumping mouse and, therefore, receives protection under state law.

Three federally listed endangered wildlife species potentially occur at Rocky Flats: the black-footed ferret, peregrine falcon, and bald eagle (ASI 1991). Potential habitat for several Colorado "Category 2" wildlife species occurs at Rocky Flats. These are the ferruginous hawk, Preble's Meadow Jumping Mouse, white-faced ibis, mountain plover, long-billed curlew, and swift fox (ASI 1991). Small size and lack of an appropriate prey base precludes OU 7 as an important habitat for these federally listed or Category 2 species (DOE 1994a). Four plant species potentially present at Rocky Flats include one federally listed threatened species, Ute lady's tresses, one Category 2 species, Colorado butterfly plant, and two species of concern in Colorado, forktip three-awn and toothcup. None of these plant species have been found at Rocky Flats (DOE 1995b).

9.2.2 Wetlands/Floodplains

Approximately 50 percent of the wetlands located on the east edge of the landfill boundary (the East Landfill Pond) would be left in place after the landfill closure activities are completed. The landfill pond currently has a total area of approximately 2.26 acres. The proposed engineered landfill cover design would include an area extending over a portion of the pond. Wetlands mitigation will be performed in

conjunction with other Rocky Flats wetlands mitigation at the 80 acre Standley Lake Protection Project

The closest 100-year floodplain to the proposed IM/IRA activities is along Woman Creek (approximately 1 mile to the south) and the proposed action would not alter or impact the 100-year floodplain configuration (DOE 1992d)

Short-Term (Construction Period) Impacts

Potential impacts to the wetlands can occur from sediment loading from storm water runoff and surface disturbance during construction activities. Surface water control measures would be used to minimize surface water from contacting potentially contaminated soil/groundwater and minimize erosional effects during the construction activities. Precipitation falling on areas where construction is in progress would be diverted to existing surface interceptor ditches along the north and south boundaries of the site. Other shallow ditches and silt fences would be constructed to prevent significant sediment from flowing into the landfill pond. Newly constructed soil surfaces would be properly protected using methods described in Section 9.5 to minimize soil erosion until the required vegetation is established.

Long-Term Impacts

The East Landfill Pond includes approximately 3 percent of the open water habitat and 6 percent of the available shoreline habitat at RFETS, the adjacent wetlands represents approximately 1.6 percent of the total (COE 1994). Since the East Landfill Pond was constructed only about 20 years ago, it is probably not a historically important component of the local ecosystem. The importance of the East Landfill Pond to aquatic life at RFETS and the Big Dry Creek basin appears to be minimal. The pond apparently does not contain fish or crayfish populations, if it does, the populations are very small. Without a complex aquatic food web that includes upper-level aquatic consumers, the pond is a limited resource for aquatic-feeding wildlife. The lack of upper-level aquatic consumers may also help attenuate the transfer of contaminants via food web interactions (Rasmussen et al. 1990). The East Landfill Pond does not empty directly into a stream under normal flow conditions, however, large rain storms would cause the pond to overflow into streams, but would occur rarely and not enough to sustain fish. Therefore, sensitive aquatic fauna such as the fish common shiners and stonerollers are not at risk from release of contaminants into streams. Because the pond lacks redaceous fish such as bass, it may be a resource for breeding amphibians such as tiger salamanders, chorus frogs, and bullfrogs.

9.3 Impact to Air Quality

The purpose of this section is to assess the potential impacts to air quality associated with the proposed installation and maintenance of the engineered cover and the potential off-gases from the OU 7 landfill. This assessment includes

- estimation of potential fugitive dust emissions
- estimation of downwind airborne particulate concentrations at the RFETS property boundary using an EPA screening level model
- comparison to EPA air quality standards
- estimation of potential methane emissions

Estimation of Potential Fugitive Dust Emissions

Fugitive dust emissions arising from construction activities may be estimated by identifying the type of equipment and capacities expected to be used, the volume of earthen materials, travel distances, and climate conditions. Construction involved with the IM/IRA includes three representative tasks

- construction of a haul road between Western Aggregates, Inc. and the OU 7 landfill
- transport of fill and cover material to the landfill
- installation of the engineered cover over the landfill

Post-construction activities will include monitoring and maintenance of the cover. The landfill contents are covered with operational soil cover as it is placed, so the landfill contents will be covered before IM/IRA construction activities begin. Materials used for the fill and engineered cover include clay, sand, gravel, and topsoil, with vegetation developed after construction is complete.

The construction tasks will require the use of bulldozers, compactors, water trucks, and haul trucks. Because of the transport distances, it is not expected that the use of scrapers will be economically feasible. EPA has developed empirical equations for estimating dust emissions from typical construction equipment (EPA 1995). The equations used to represent emission rates from anticipated OU 7 construction activities include operation of haul trucks on unpaved roads, dumping of haul truck contents, and operation of bulldozers/compactors.

$$\text{Bulldozer } E F = 10(s)^{1.5}(M)^{1.4}$$

where

- $E F$ = Emission factor (lb/hr)
 s = Silt content of on-site soil (assumed 10 percent)
 M = Moisture content of soil (assumed 10 percent)

Two bulldozers and two compactors were assumed. A 25 percent reduction was applied to estimate respirable particulate matter (PM-10) emissions (EPA 1995). A 50 percent reduction was applied to account for dust control from periodic watering applied by the contractor's watering trucks.

$$\text{Dumping } E F = K(0.0032) \left(\frac{U}{5}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$$

where

- $E F$ = Emission factor (lb dust per ton dumped [lb/ton])
 k = particle size multiplier = 0.35 (PM-10) (EPA 1995)
 U = Mean wind speed, miles per hour (mph) (assumed 8 mph)
 M = Moisture content of soil (assumed 10 percent)

Approximately 25 to 30 haul trucks will be used. Equation valid for silt content of on-site soil assumed 10 percent. A 50 percent reduction was applied to account for dust control from watering.

$$\text{Transportation } E F = K(5.9) \left(\frac{s}{12}\right) \left(\frac{S}{30}\right) \left(\frac{W}{3}\right)^{0.7} \left(\frac{w}{4}\right)^{0.5} \left(\frac{365-p}{365}\right)$$

where

- $E F$ = Emission factor (lb per vehicle mile traveled [lb/VMT])
 K = Particle size multiplier = 0.36 PM-10 (EPA 1995)
 s = Silt content of on-site soil (assumed 10 percent)
 S = Mean vehicle speed (assumed 15 miles per hour)
 W = Mean vehicle weight (assumed 25 tons)
 w = Mean number of wheels (assumed 18)
 p = Number of days per year with precipitation greater than or equal to 0.01 inches = 87 (EPA 1995)

Approximately 25 to 30 haul trucks will be used. A 99 percent reduction was applied to account for dust control from periodic watering applied by the contractor's watering trucks, e.g., near 100 percent effectiveness has been obtained with applications of 0.125 gallons per square yard every 20 minutes (DOE 1992c).

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Each of the three representative construction tasks involves different assumptions regarding distances, material volumes, and equipment usage, which result in different estimated emission rates. These emission rates are then used as input to the conservative EPA screening model Screen2, which is a module of Tscreen (EPA 1994b). Screen2 was used assuming worst-case downwind dispersion conditions to calculate airborne particulate concentrations at the RFETS property boundary. The emission rate for dumping truck contents assumes a higher wind speed (8 miles per hour) than that assumed in the air dispersion model (2.2 miles per hour). These are reasonable worst-case assumptions because greater emissions result during higher wind speeds, but the least amount of dispersion occurs during low wind speeds. The assumptions, estimated emissions, and dispersion modeling results are presented in the following sections for each of the three representative construction tasks.

9.3.1.1 *Haul Road Construction*

The construction haul road will be built between the nearby borrow source, Western Aggregates, Inc., and the landfill. The distance required will be at most 2.5 miles. With an approximate width of 30 feet, the total area is approximately 9 acres. The road will be built with approximately 8,000 yds³ of aggregate road base, with an assumed silt content of 10 percent. At 15 yds³ per truck, 533 round trips (loads or number of dumps) would be required to build the road. Trucks will only need to travel short distances as the road is started, and travel the entire length of the road as it is finished. Using half the length to represent the average round trip distance, a total of 1,333 vehicle miles are required. It is expected that construction of the road will require approximately 10 working days using two bulldozers and two compactors.

These estimations of vehicle miles traveled and durations of activities were used as input to the equations for estimating emissions. The emissions from constructing the haul road, which are displayed in the second column of Table 9-2, indicate that haul truck transportation is expected to contribute the majority of emissions for this task.

For use as input to the air model, the emissions were input as g/s, and the area of the road as 9 acres (36,400 m²). Since the trucks will be traveling back and forth along the road, and the distance to the west (closest) property boundary will change continuously, the average emissions location was assumed to be the midpoint between the borrow pit and the landfill. The distance to the fence line at this point is approximately 1,300 m. The estimated airborne particulate concentrations are summarized in Section 9.3.2.

9.3.1.2 *Transport of Fill and Cover Material to the Landfill*

An estimated 243,480 yds³ of clay, sand, gravel and topsoil will be needed as fill and cover material. At 15 yds³ per truck and a round trip distance of 5 miles, a total of 81,160 vehicle miles are required during an estimated duration of 500 work-hours.

Since the transport and installation of the cover will be overlapping activities, and the dumping of the haul truck loads will occur at the landfill, dumping has been considered as part of the cover installation (see Section 9 3 1 3). The estimation of vehicle miles traveled was used as input to the equations for estimating emissions, along with standard default values. The emissions from transporting the fill/cover material are displayed in the third column of Table 9-3.

Similar to the discussion in Section 9 3 1 1, the transport emissions were input as g/s, the area of emissions was assumed to be 36,400 m², and the average distance to the fence line assumed to be approximately 1,300 m. The estimated airborne particulate concentrations are summarized in Section 9 3 2.

9 3 1 3 *Installation of the Engineered Cover over the Landfill*

Installation of the fill/cover material at the landfill will include dumping of the haul truck loads, spreading with 2 bulldozers, and compaction with 2 compactors. It is estimated that 500 work-hours will be needed to install the material. This duration was input to the equations for dumping haul truck loads and operating bulldozers, along with standard default assumptions. The results for installation of the fill/cover material, which are presented in the fourth column of Table 9-3, indicate that bulldozer/compactor operations are expected to contribute the majority of emissions for this task.

These estimated emissions were input to the Screen2 air model as g/s, the area of emissions was assumed to be the area of the landfill, 28 acres or 113,300 m², and the average distance to the fence line assumed to be approximately 2,550 m. The estimated airborne particulate concentrations are summarized in Section 9 3 2.

Emissions of fugitive dust from the cover surface were not addressed quantitatively due to the extensive watering expected to be applied by the contractor. The earthen materials of the cover layers are installed in many sub-layers as the work progresses. Each sub-layer is watered to ensure proper moisture content and compaction. The exposed cover must be kept moist during work-days, nights, and weekends to prevent drying and cracking (loss of the cover integrity). Keeping the cover moist is typically accomplished through the application of water by watering trucks, or by covering the completed sub-layer with a loose lift of moist clay clumps. The clay clumps tend to dry over weekends, but have low potential as a source of respirable particulates.

9 3 2 *Comparison to EPA Air Quality Standards*

The state and federal 24-hr PM-10 standards and annual standards are 150 ug/m³ and 50 ug/m³, respectively. Table 9-3 presents the modeled and cumulative PM-10 concentrations for the reasonable worst-case scenario.

As presented in Table 9-3, under reasonable worst case conditions, respirable dust concentrations are not expected to exceed the 24-hr standard of 150 ug/m³ at the property boundary during the construction activities. Similarly, emissions are also expected to be well below the annual standard.

9.3.3 Estimation of Potential Methane Emissions

Methane emissions from the OU 7 landfill may be estimated from the volume of the waste contents. The approximate volume of waste is expected to be 404,000 yds³ in 1997, with 124,000 yds³ of daily soil cover (DOE 1994a). The methane and carbon dioxide content of the soil gas is 60 percent and 40 percent, respectively, indicating anaerobic conditions (DOE 1994a). Concentrations of these gases are highest in the younger, eastern portions of the landfill.

Measurements of other landfills with similar conditions support an average emissions factor for landfill gas (LFG) of 0.1 ft³/lb refuse/yr (DOE 1994a). This value is typical of landfills in drier climates, as compared to values ten or more times greater in moist climates (Tchobanoglous et al., 1992). In order to use this empirical approach to estimate LFG emissions, it is necessary to calculate the weight of landfill contents. The density of the individual items in the landfill varies, but the average density of contents is assumed to be approximately 1,000 lb/yds³ (DOE 1994a). Multiplying 404,000 yds³ times 1,000 lb/yds³ provides a total weight of landfill contents of 4.04E+08 lb.

The emission rate of LFG is calculated by multiplying the average emissions factor, 0.1 ft³/lb refuse/yr, by the total weight of the landfill contents, 4.04E+08 lb. The calculated result, 4.04E+07 lb LFG/yr, is multiplied times the percent methane content, 60 percent, to determine methane emission rates. The resulting average annual emission rate of methane is 2.42E+07 ft³/yr, and is characteristic of the low generation rates of medium size landfills in drier climates (Tchobanoglous et al., 1992). The result is a conservative over-estimate since it assumes the older wastes are producing methane at the same rate as younger wastes. The generation rate is also similar to that expected from the new Rocky Flats landfill and is roughly equivalent to the annual methane produced by several hundred cattle (DOE 1994f).

9.4 Impact to Surface Water Quality

Short-Term (Construction Period) Impacts

Construction activities from the proposed landfill closure activities would result in surface disturbance from the clearing of vegetation, excavation/salvage of topsoil material, blading/leveling of land preceding construction, and the potential for accidental uncovering of contaminated media. Potential impacts to surface water during the construction phase include increased erosion, contamination from water

contacting uncovered contaminated media, and subsequent sediment loading to drainage ditches and the East Landfill Pond during storm events. The absence of vegetative cover and the steepening of slopes would result in increased potential for both sheet and channelized runoff and wind and water erosion, subsequently resulting in increased sedimentation of ditches and the East Landfill Pond.

The proposed action is limited to constructing an engineered cover system for containment of the landfill waste and contaminated media. Construction would require clay, sand, and gravel obtained from offsite commercial operations. The excavation of these borrow materials would have impacts similar to those identified above, which are addressed in permits issued for the offsite facilities. The proposed construction activities are not expected to have any physical contact with contaminated media or waste material. In the event that equipment and personnel come in contact with potentially contaminated materials during construction, decontamination would be performed at the Rocky Flats decontamination facility to reduce potential impacts to surface water. Given the expected conditions, no significant surface water impacts from contaminated media are expected.

The total area of disturbed soils would be approximately 39 acres, including the area of the landfill to be resurfaced (28 acres), haul roads to the offsite borrow areas (9 acres), and miscellaneous construction activities (2 acres). Surface water control measures would be used to minimize surface water from contacting potentially contaminated soil/groundwater and minimize erosional effects during the construction activities. Precipitation falling on areas where construction is in progress would be diverted to existing surface interceptor ditches along the north and south boundaries of the site. Other shallow ditches would be temporarily constructed as needed to prevent sediment laden stormwater from flowing directly into the East Landfill Pond. Newly constructed soil surfaces would be properly protected using soil terracing, hydromulch, straw-mulch, silt fencing, etc. to minimize soil erosion and surface water degradation until the required vegetation is established. Average potential loss of soils from newly constructed surfaces due to water erosion is estimated at 6 tons/acre/year for the first two years during and after construction activities. This loss was estimated using the Universal Soil Loss Equation (USLE) (SCS 1984). The use of straw-mulch, adequately spaced silt fences, and other appropriate measures would minimize this potential and allow the final vegetative cover to be established within 2 to 3 years. Potential soil loss from surfaces with established vegetation similar to surrounding areas is estimated at 1 to 2 tons/acre/year.

Long-Term Impacts

Long-term protection is maximized because the proposed IM/IRA engineered cover will minimize infiltration of precipitation and subsequent contact with contaminants.

and will incorporate surface drainage features to prevent run-on/run-off and to provide erosion control. The proposed action will ultimately result in a decrease in the risk of contaminants reaching surface water by eliminating the possibility of precipitation contacting contaminated soils or waste. Precipitation falling within the boundary of the landfill will be drained off of the cover using the most efficient pathway and diverted away from the landfill. Surface water drainage from areas outside the landfill boundary would be prevented from flowing onto the landfill and diverted around the landfill boundary. Using appropriate surface reclamation measures, adequate vegetation cover should be established on the final surface of the landfill in 2 to 3 years. The establishment of vegetative cover on stabilized slopes, contours of the landfill, and the surrounding disturbed surfaces would greatly reduce erosional hazards to levels similar to surrounding areas.

Post-closure monitoring activities would include observations of the landfill surface and associated drainage ditch conditions and will continue for 30 years on a semi-annual basis. Observations of the vegetative cover and evidence of soil erosion and loss would be included in the monitoring efforts. Maintenance activities consisting of further erosion control measures, regrading, and revegetation would be implemented if monitoring observations indicate that the landfill surface reclamation is not effective as planned.

9.5 Impact to Groundwater Quality

Sources of groundwater recharge to the UHSU include infiltration of precipitation, snowmelt, storm runoff, and downward seepage from the East Landfill Pond. The level of groundwater rises annually in response to spring and summer recharge and declines during the remainder of the year. Groundwater generally flows to the east, however, localized flow follows topographic slopes toward the pond or toward the drainage below the dam. Groundwater intermittently flows to the east within the saturated valley-fill alluvium. The average depth to, and saturated thickness of, groundwater in the landfill mass is approximately 20 and 11 feet, respectively.

Short-Term (Construction Period) Impacts

Local impacts to groundwater flow direction and possibly hydraulic gradient would be expected because of the engineered cover reducing surface water infiltration, however, enhanced groundwater quality would be a result from reducing water flow through waste. The slurry wall installed as part of the landfill maintenance program would be expected to greatly reduce the volume of upgradient groundwater from flowing through the landfill mass. The engineered cover system constructed as part of this IM/IRA would also minimize surface water infiltration and isolate contamination from surface water contact.

An estimate of potential infiltration and percolation through the proposed engineered cover system was performed using the HELP Version 3 computer model (EPA 1994c)

A summary of the HELP modeling is presented in Section 6 of this document. Specific HELP model runs are presented in Appendix F. The proposed cover design, other alternative cover design sections and the no-action alternative were modeled. The results of the HELP model computations for the proposed engineered cover design indicate that the potential average annual leakage through the engineered cover is approximately 1.5 inches/acre/year. The leakage rate of the existing landfill interim cover is estimated to be 7.5 inches/acre/year. This indicates that the engineered cover would reduce the amount of precipitation infiltration that would potentially flow through waste layers by at least 80 percent. The HELP model does not account for capillary flow in the variably saturated components and as a consequence, provides a conservative estimate of percolation through the engineered cover.

As discussed in Section 2.3, a water balance was performed for the landfill mass using the MODFLOW (McDonald and Harbough 1991) computer model with site specific data for the no-action alternative. The water balance calculations indicate that approximately 60 percent of the landfill mass inflow is groundwater from the alluvium and 40 percent is recharge by infiltration of precipitation. Most of the groundwater inflow (90 percent) occurs on the north side of the landfill. Contributions from the west side (10 percent) and the south side (0 percent) are relatively insignificant. The water balance shows that both the proposed engineered cover system and slurry wall on the north side of the landfill would minimize additional water inflow and leachate generation. The water balance calculations for the landfill mass inflow are presented in Appendix C.

The surface water diversion ditch would divert storm water runoff around the landfill, resulting in further reduction of surface infiltration and groundwater recharge through waste.

Long-Term Impacts

The eventual effects of constructing the low permeability cover would be a significant reduction in saturated thickness of the waste material. In conjunction with the slurry wall diverting upgradient groundwater around the landfill mass and the reduction of surface water infiltration, a 60 to 80 percent reduction of water flow through the waste mass would be expected. A significant reduction of the saturated waste would result in reduced leachate generation and reduced potential for migration of leachate into groundwater.

The overall impact to groundwater from the proposed IM/IRA would be the enhancement of the groundwater quality at the site. No significant negative impact to groundwater quality is expected from the proposed action.

9.6 Commitment of Irreversible and Irretrievable Resources

The proposed IM/IRA would result in some permanent commitments of resources, but would not be expected to result in a substantial loss of valuable resources. Most of the resources used for the construction of the engineered cover will be permanently committed to the implementation of the remedial action. Irrevocable and irretrievable commitments of resources are defined as those which are either consumed, committed, or lost, and for this project they include the following:

- Consumptive use of geological resources (e.g., quarried rock, sand, and gravel) and petroleum products (e.g., fuels) will be required for construction activities of the selected remedy. Supplies of these materials will be provided by the construction contractor. The selected remedy will result in a permanent commitment of 243,480 cubic yards of clay, sand, gravel, and topsoil from onsite and offsite sources to construct the final engineered landfill cover. However, adequate supplies are available without affecting local requirements for these products.
- Fuel consumed in construction equipment and vehicles for the construction of the landfill cover will never be recovered.
- Soil at the site will be disturbed by construction activities. Many impacts will be temporary, pending completion of remedial activities and restoration programs.
- Resources that may underlie the landfill will be lost if retrievable using conventional excavation methods. However, there appear to be no commercially exploitable mineral resources in the Rocky Flats security zone (DOE 1980).
- Commitment of up to 28 acres of land as a landfill, which will permanently be committed and constrained to limited land use options.
- Wetlands and associated natural resource services will be reduced at the site as a result of the selected remedy. Long-term direct impacts to the floodplain resulting in changes of flood elevations will not occur.
- Long-term commitment of personnel and funds to perform post-closure monitoring and maintenance operations.
- Maintenance activities will be performed as necessary. Long-term environmental impacts would not be expected to occur from the OU 7 selected remedy. Monitoring and periodic site inspections would be performed to ensure long-term protection of human health and the environment.

As a result of the constructed engineered cover and the network of monitoring wells to remain in-place, commercial, industrial, and residential land use will be permanently prohibited within the landfill boundaries. Appropriate landfill surface reclamation will result in an acceptable appearance of the remediated site and the ecological succession of the closed landfill and adjacent land will be improved by surface revegetation, similar to surrounding areas.

Incidental resources that will be consumed, committed, or lost on a temporary and/or on a partial basis during construction include construction personnel/equipment, the construction water source, and the construction materials used for equipment haul roads. During construction of the proposed IM/IRA, it is expected that 20 to 35 non-Rocky Flats personnel would be required for the duration of the construction activities (approximately 4 to 6 months). The raw water supply available at the plant will be used in order to conserve water that is treated by the Rocky Flats water treatment plant.

The compacted soil portion of the engineered cover system would require 8,000,000 to 10,000,000 gallons of water over the duration of the construction activities. Approximately 7,000 to 8,000 cubic yards of material will be temporarily used for the construction of the haul roads. This material will be salvaged and available for reuse.

9.7 Impact to Transportation

The proposed IM/IRA would be expected to cause minimal direct and indirect impacts to the transportation systems in and surrounding RFETS. The majority of the materials necessary for the construction of the engineered cover system (clay, sand, and gravel) will be transported using tandem semi-trucks or earthmoving scrapers from the nearby offsite borrow source, Western Aggregate Supply Company, located to the northwest of the site. A construction haul road (approximately 2.5 miles long) will be constructed from the offsite borrow pit to the site. The construction haul road will be paved with aggregate road base only. The new haul road will result in no impact to Colorado State Highway 93. Other construction materials and supplies, as well as construction mobilization equipment and construction personnel, will be using the available RFETS and public transportation systems. However, traffic impacts from this would be expected to be minor.

9.8 Impact to Cultural/Historical and Archaeological Resources

No known significant cultural, historical or archaeological resources would be expected to be impacted by the proposed IM/IRA activities (CHS 1992).

9.9 Cumulative Impacts

Cumulative impacts may result from the combination of incremental impacts from past, present, and reasonably foreseeable future actions. Cumulative impacts could have the

potential of being more significant than the individual impacts due to synergism between types and areas of impact, or the individual impacts collectively resulting in significant effects to the environment. There are no other activities scheduled for the OU 7 area that would be expected to cause significant impacts to the area. Ongoing maintenance and groundwater and landfill gas monitoring will be limited to short-period sampling events. Construction activities at other OUs at Rocky Flats will also continue in the future, but these activities are not likely to overlap due to the lengthy process of design, approval, and implementation. Therefore, expected short-term future cumulative effects would not be substantial. Long-term cumulative impacts (i.e., IM/IRA activities in conjunction with other site restoration activities) will facilitate future beneficial use of Rocky Flats land and fulfill mandated cleanup objectives.

The following types of cumulative impacts may occur:

- Increased construction personnel would have an additive effect on existing workload for plant operations. This effect is short-term, however, operation/maintenance activities would continue during the post-closure period. The anticipated workload of the operation/maintenance personnel would be significantly less than what is required currently.
- Potential waste generated by this proposed action would be very limited and may include small amounts of soil from construction activities, potentially contaminated water from decontamination operations, and water generated from sampling activities during groundwater monitoring. The small amounts of waste generated would be insignificant and any impacts would be negligible.
- Wetlands mitigation would be necessary to replace the portion of the East Landfill Pond that would be covered by implementation of the engineered cover system. Potential cumulative impacts, such as other sitewide wetlands mitigation requirements and disturbing the environment of new wetlands areas, could be expected as the wetlands mitigation would probably be performed in an entirely different area of the site or offsite.

9.10 Comparison of the Preferred IM/IRA to the No Action Alternative

The potential adverse and beneficial impacts of the two alternatives are expected to be significantly different in the magnitude to which they affect the quality of the environment. Implementation of the proposed IM/IRA is not expected to have any substantial adverse impacts to human health or the environment and is consistent with long-term remediation goals for Rocky Flats. For the instances where potential impacts may occur, effects are expected to be small and temporary and appropriate mitigation measures would be implemented.

The no-action alternative could have potentially adverse impacts to both human health and the environment by allowing contaminated media to remain in-place and allowing exposure to humans and biotic components of the environment. Therefore, the no action alternative would potentially allow for direct or indirect receptor intake. A comparison of how the two alternatives could impact human health and the environment is presented in Table 9-4.

Table 9-1
Summary of Uncertainties

Issue	Remarks	Potential Impact On Exposure
Assumptions regarding duration of work activities	Actual durations of activities at the site may differ from planning assumptions	Slightly over- or underestimate
Assumptions regarding construction materials	The potential for particulate emissions from actual construction materials used at the site may differ from planning assumptions	Slightly over- or underestimate
Assumption that construction activities will not involve intrusion into landfill contents	Intrusion into landfill contents is not anticipated. However, if this became necessary, worker protection would be addressed by health and safety precautions	Slightly underestimate
Estimation of emission rates	Emission rates are estimated for construction activities using empirically derived EPA algorithms	Moderately over- or underestimate
Use of a screening level transport model (gaussian dispersion in air)	Screening level models are based on conservative, bounding assumptions and algorithms	Moderately overestimate
Assumptions about receptor locations	Worker exposure may vary depending on the proximity to the dust emission sources. Dust concentrations were modeled at the property boundary, but current residential receptors are located more than a mile away from this point	Moderately overestimate
Occupational exposure limit for nuisance dust	Limits are based on observation of human exposure and are reasonable upper bound values	Moderately overestimate
Heavy equipment and vehicle accident risk	These are addressed by occupational regulations. Transportation will be on private roads at low speeds	Slightly under- or overestimate

Table 9-2
Emissions from Construction Task (g/s)

Source	Construct Haul Road	Transport Fill/Cover	Install Fill/Cover
Haul Truck	0 132	0 721	NA
Dumping Load	0 001	NA	0 010
Bulldozer	0 238	NA	0 238
Total	0 37	0 72	0 25

Table 9-3
Modeled and Cumulative PM-10 Concentrations for OU 7 IM/IRA

Task	Averaging Period	Model Input (g/s)	Modeled Concentration (ug/m ³)	Background ¹ Concentration (ug/m ³)	Cumulative ² Concentration (ug/m ³)
Haul Road Construction	24-hour	0 37	26 1	47	73
	Annual		2 1	15	17
Transport of Fill and Cover Material	24-hour	0 72	52 1	47	99
	Annual		8 9	15	24
Installation of Engineered Cover	24-hour	0 25	6 6	47	54
	Annual		1 1	15	16

1 Rocky Flats Plant Site Environmental Report (DOE 1993)

2 Cumulative concentrations are estimated by adding the modeled concentrations to the measured PM-10 background concentrations

Table 9-4
Summary of Potential Impacts:
Preferred IM/IRA Versus No Action

Impact	Preferred IM/IRA	No Action
Human Health	<p>Reduce or eliminate existing risks to long-term exposures from potential contaminated soil</p> <p>Short-term risks of exposure to site workers, plant workers, and public from construction activities (e.g., increased fugitive dust, increased traffic)</p> <p>Potential short-term risks to personnel as a result of inadvertently disturbing landfill waste areas with high levels of contamination</p> <p>Risk to personnel as a result of contacting contaminants during groundwater monitoring/sampling</p>	<p>Risks to onsite and offsite persons as a result from long-term exposure to potential contaminated soil, airborne contaminants, contaminated surface water and groundwater</p> <p>No risks of exposure to construction workers</p> <p>Potential risks to personnel as a result of inadvertently disturbing landfill waste areas with high levels of contamination</p> <p>Risk to personnel as a result of contacting contaminants during groundwater monitoring/sampling</p> <p>Potential risks of contaminating downgradient groundwater and surface water</p>
Environment	<p>Short-term disturbance of the site and immediate area during construction activities, more than 39 acres will be disturbed by construction activities</p> <p>Short-term disturbance of the borrow site where soil materials will be obtained for the construction of the cover</p> <p>Increases in local traffic, fugitive dust, combusted fuels due to construction activities, potential erosion due to surface disturbances during construction and topographical changes of the site and the borrow area</p> <p>A portion of the East Landfill Pond, a wetlands area, will be covered by the engineered cover system. Wetlands mitigation would be performed after landfill closure is complete</p> <p>No floodplains will be affected</p> <p>Some critical habitat of the Preble's Meadow Jumping Mouse would be covered by the placement of the engineered cover</p>	<p>Contaminated media would remain in-place for exposure to humans and environment</p> <p>Uncontrolled contaminants and waste could negatively affect vegetation and wildlife and impact receiving surface water and groundwater</p> <p>The East Landfill Pond, a wetlands area, would be potentially affected by leachate and/or groundwater contamination</p> <p>No floodplain, critical habitats, or threatened and endangered species would be affected</p>

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Impact	Preferred IM/IRA	No Action
Air Quality	<p>Landfill offgases could potentially impact the air quality at and nearby the site. The proposed engineered cover system includes a gas collection layer that would provide some control of landfill offgases as well as an optional future collection system.</p> <p>The construction of the haul road to be used to transport fill material would affect air quality during construction activities. However, control measures would be implemented to minimize the effects.</p> <p>The material hauling and the construction of the engineered cover would affect air quality during construction activities. However, control measures would be implemented to minimize the effects.</p>	<p>Landfill offgases could potentially impact the air quality at and nearby the site and will continue to be uncontrolled.</p> <p>No increase in dust emissions.</p>
Groundwater Quality	<p>The eventual effect of constructing the low permeability cover would be a significant reduction of the saturated waste, leachate generation and potential for migration of contaminants.</p> <p>Potential effects on local hydrogeologic characteristics by reducing groundwater inflow and changing topography in a groundwater recharge area.</p>	<p>Downward migration of site contaminants would continue.</p> <p>Potential for contaminant migration to downgradient groundwater.</p>
Surface Water Quality	<p>Coverage of waste under engineered cover will minimize or eliminate potential for contaminated surface water runoff.</p>	<p>Potential for surface water runoff to contact waste and transport contamination into surface water bodies.</p>
Cultural, Historical, and Archaeological Resources	<p>No resources present.</p>	<p>No resources present.</p>
Transportation	<p>Minor increase in traffic volume and patterns during construction activities, negligible impact on surrounding transportation infrastructure.</p>	<p>No increase in traffic volume.</p>

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Impact	Preferred IM/IRA	No Action
Short-term vs Long-term uses	Implementation of the proposed IM/IRA is not expected to have substantial adverse short-term or long-term impacts to human health or the environment The IM/IRA is consistent with long-term remediation goals for RFETS	The no action alternative would have no significant short-term impacts, with the exception of land use. Most of the site would remain as uninhabitated wildlife habitat The no action alternative could have potentially adverse long-term impacts to both human health and the environment with remaining contaminated media in-place potential exposure
Irreversible & Irretrievable Resource Commitments	Clean fill from onsite and offsite borrow areas, construction materials, and very limited land use or resources beneath the site Resources to implement the proposed IM/IRA would be lost or consumed (i.e., capital, fuel, manhours, construction water, etc.)	Very limited land use and resources beneath the site
Cumulative Impacts	Implementation of the IM/IRA is consistent with the long-term mission of remediating RFETS Implementation may interfere slightly with other activities in progress at RFETS Short-term increases in personnel at the site would result from the implementation of the IM/IRA Wetlands mitigation may be necessary	Implementation of the no-action alternative would impede or delay long-term site-wide goals of remediation The no action alternative could have potentially adverse impacts to both human health and the environment with remaining contaminated media in-place for exposure to humans and environment
Mitigation Measures	Because a portion of the existing wetlands (East Landfill Pond) will be under the engineered cover, it may be necessary to mitigate lost wetlands Potential mitigation of surface runoff and erosion from the construction area may be necessary	Future mitigation of contaminant migration may be necessary

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328/328

ADD from 10

MISS - was to be prepared 1955



EXPLANATION

Artificial fill

Quaternary

Landslide (Qls)

Colluvium (Qc)

Valley-Fill Alluvium (Qvf)

Rocky Flats Alluvium (Qrt)

Cretaceous

Undifferentiated Arapahoe/
Laramie Formation (Kaki)
(Claystone)

Geologic Contact
(dashed where inferred)

USE NEW TOPOGRAPHY

0 Feet 250 500

Topographic Contour Interval = 20 feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats, Site, Golden, Colorado

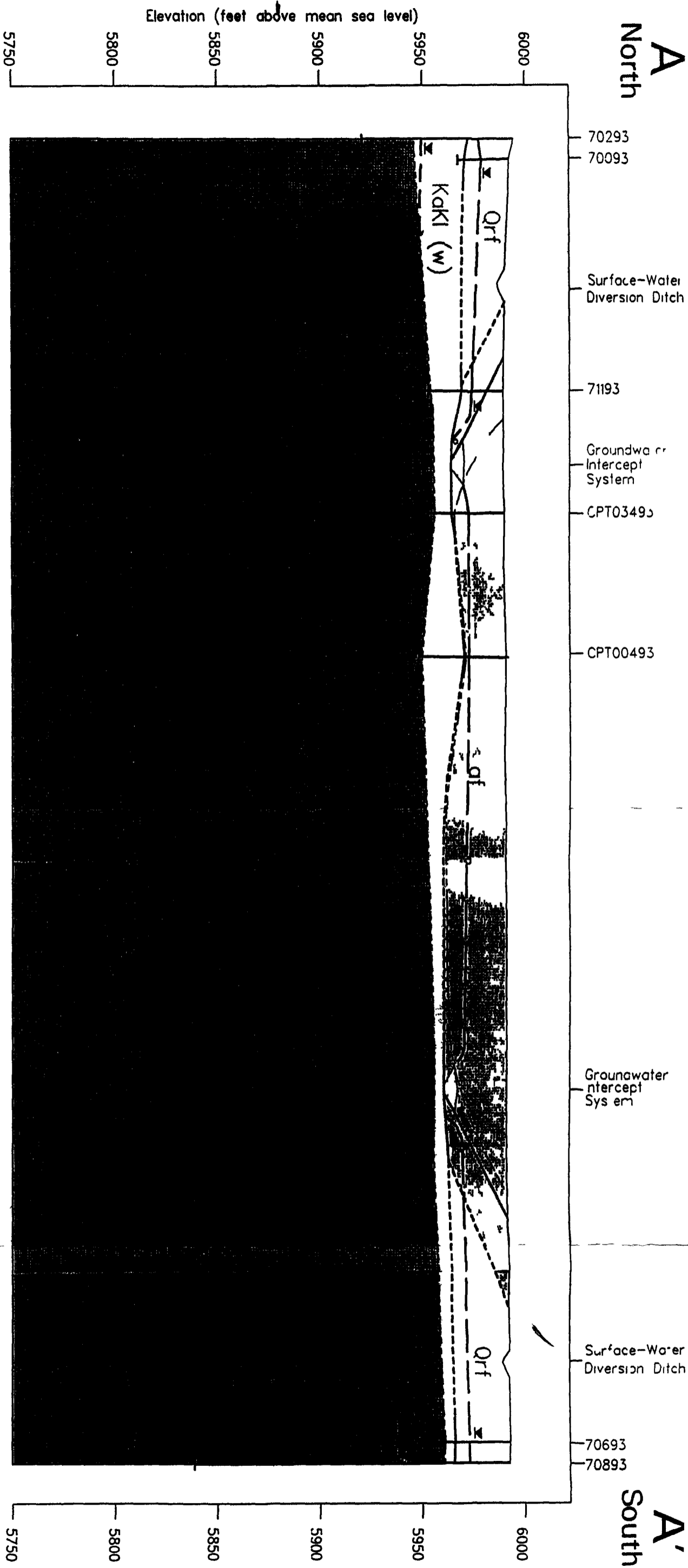
Environmental Technology

Geologic Map
of

Surficial Materials

July 1975
Revised Work Plan
Operable Unit No. 7

Date May 1994
Figure 2-7-4



71193
CPT00493

Well/Borehole Number
CPT Number

Approximate Ground Surface
(at time of OU 7 Phase I RFI/R)

Geologic Contact
(dashed where inferred)

Contact Between Weathered
and Unweathered Bedrock

Base of Waste Material

Estimated Potential Surface
(Upper Hydrostratigraphic Unit)
(Lower Hydrostratigraphic Unit)

Water Level Measured in March 1993

Notes 1) Refer to borehole logs (Appendix E) for detailed geologic description

2) Refer to well construction diagrams (Appendix F) for well construction details

3) Refer to CPT profiles (Appendix D) for data generated during CPT

Horizontal Scale 1 inch = 50 feet

Vertical Scale 1 inch = 50 feet

Qrt - Artificial Fill

Quaternary

Krt - Rocky Flats Alluvium

Cretaceous

Unweathered

Weathered

Horizontal Scale 1 inch = 50 feet

Vertical Scale 1 inch = 50 feet

Diversion Ditch

6187

6287
Groundwater
Intercept
System
CPT02793

6387

CPT02893

CPT00993
72093
71993

CPT02993

CPT03093

6487
B206189

CPT03193

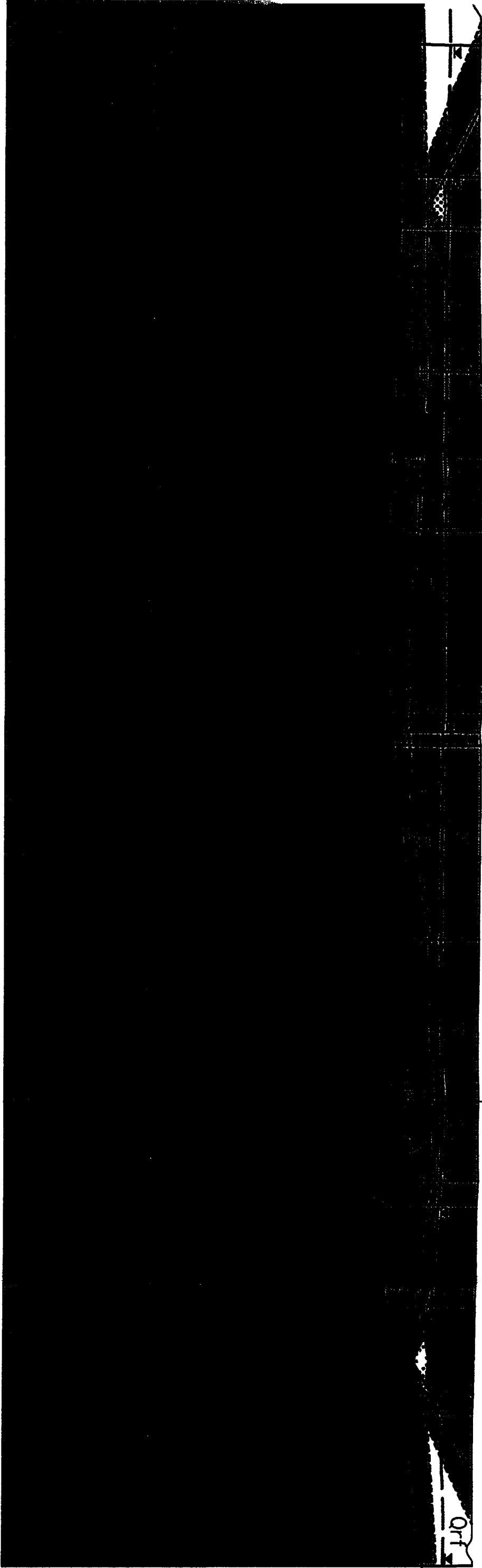
Groundwater
Intercept
System

CPT03293
6587

Surface-Water
Diversion Ditch
6687

South

6000
5950
5900
5850
5800
5750



71193

CPT00493

Well/Borehole Number

CPT Number

Approximate Ground Surface
(at time of OU 7 Phase I RI/RI)

Geologic Contact

(dashed where inferred)

Contact Between Weathered
and Unweathered Bedrock

Base of Waste Material

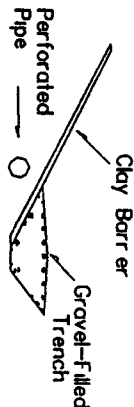
Estimated Potentiometric Surface

(Upper Hydrostratigraphic Unit)

(Lower Hydrostratigraphic Unit)

Water Level Measured in March 1993

Groundwater Intercept System



Notes 1) Refer to borehole logs (Appendix E)
for detailed geologic description

2) Refer to well construction diagram
(Appendix F) for well construction details

3) Refer to CPT profiles (Appendix D) to
data generated during CPT

Artificial Fill

Quaternary

Rocky Flats Alluvium

Cretaceous

Undifferentiated

Arapahoe and Laramie Formations

Weathered

Unweathered

Horizontal Scale 1 inch = 50 feet

Vertical Scale 1 inch = 50 feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Site, Golden, Colorado

Environmental Technology

Geologic

Cross-Section

BQ - Q'B'

July 1993
Revised Work Plan

Operable Unit No.

July 1993
Date April 1994

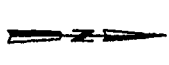
Figure 2-1/4

- EXPLANATION**
- Alluvial Well
 - Weathered Bedrock Well
 - Unweathered Bedrock Well
 - ⊕ Abandoned Well

— Line of Equal Saturated Thickness (dashed where inferred)

— Unsaturated Areas (dashed where inferred)

— Seep



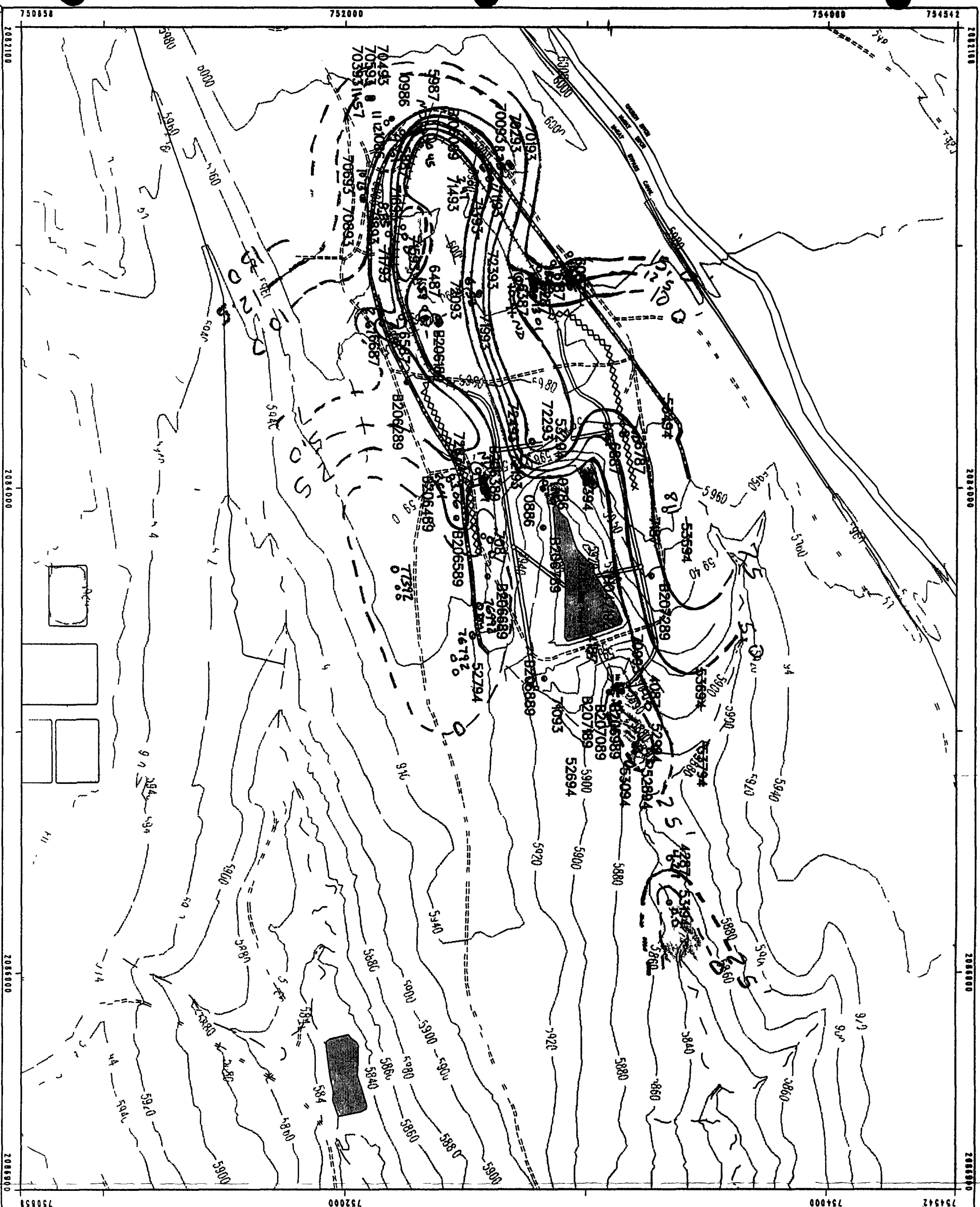
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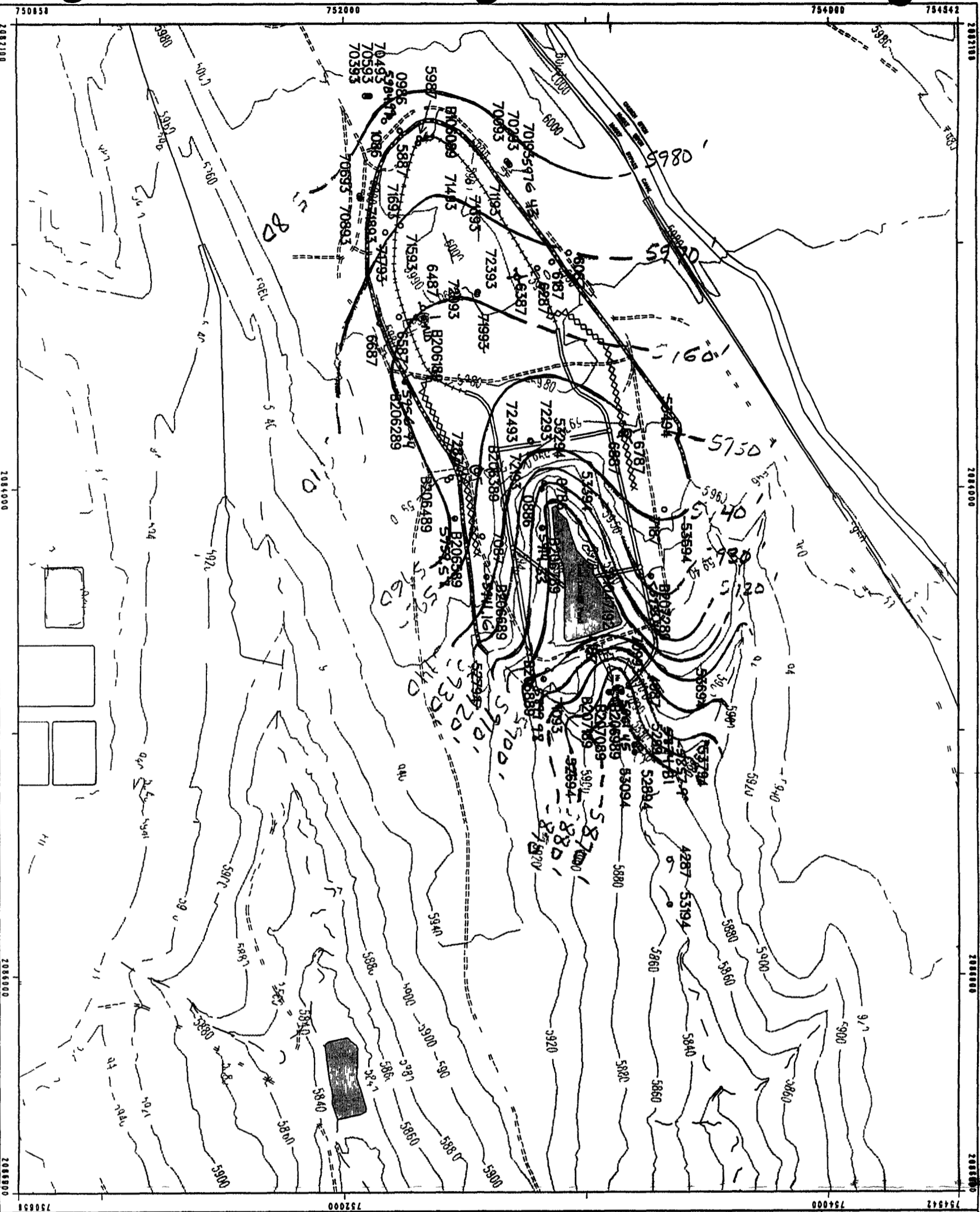


State Plane Coordinate System
Colorado Central Zone
Datum: NAD27

Saturated Thickness of Unconsolidated Surficial Deposits (2nd Quarter 1995)

Figure 2-9

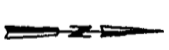




EXPLANATION

- Alluvial Well
- Weathered Bedrock Well
- Unweathered Bedrock Well
- Abandoned Well

- Equipotential Line (dashed where inferred)
- Unsaturated Areas (dashed where inferred)



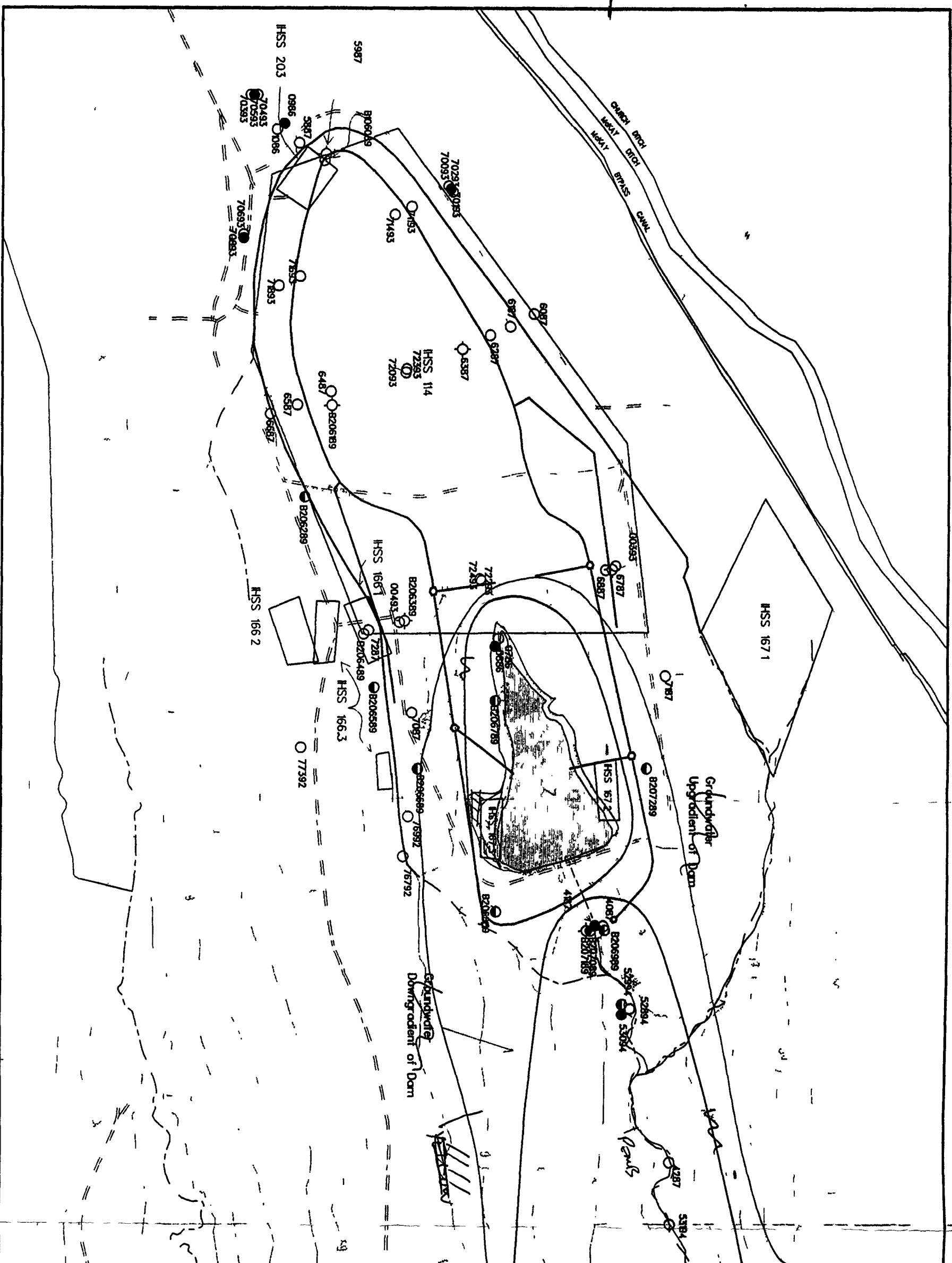
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1 inch = 400 feet

State Plane Coordinate System
Colorado Central Zone
Datum NAD27

Potentiometric Map

Weathered Bedrock (2nd Quarter 1995) 57ET

Page 2-12



EXPLANATION

- ~~3 Alluvial/Artificial Fill Well~~
- ~~2 Weathered Bedrock Well~~
- ~~1 Unweathered Bedrock Well~~
- ~~0 Abandoned Well~~

Ditch

--- Intermitent Stream

Dirt Road

~~OU 7 HHS Boundary~~

~~OU 6 HSS Boundary~~

~~Landfill Structures~~

~~Reproduction of data~~

~~1997~~ Probable Pheles Merdun
Jumping Mouse Habitat

[illegible]

0 Feet 300 600

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Site Golden, Colorado

Wetland Areas and


Groundwater Monitoring Pebble's Modular Pumping Well Network

in/ea DD Files in
~~Classroom Strategy~~ Operable Unit No. 7

July
April 1995

Figure # 2-15

EXPLANATION

- Sediment Sampling Location
- ◆ Surface Water Sampling Location
-  ~~Topography~~ *Acute Toxicity Water and Sediment Sampling Location*
- Intermittent Stream
- - - Dirt Road
- Landfill Structures



0 Feet 120 240

Topographic Contour Interval - 20 feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Site, Golden, Colorado

Environmental Technology
Surface Water

and

Sediment Sampling

Locations

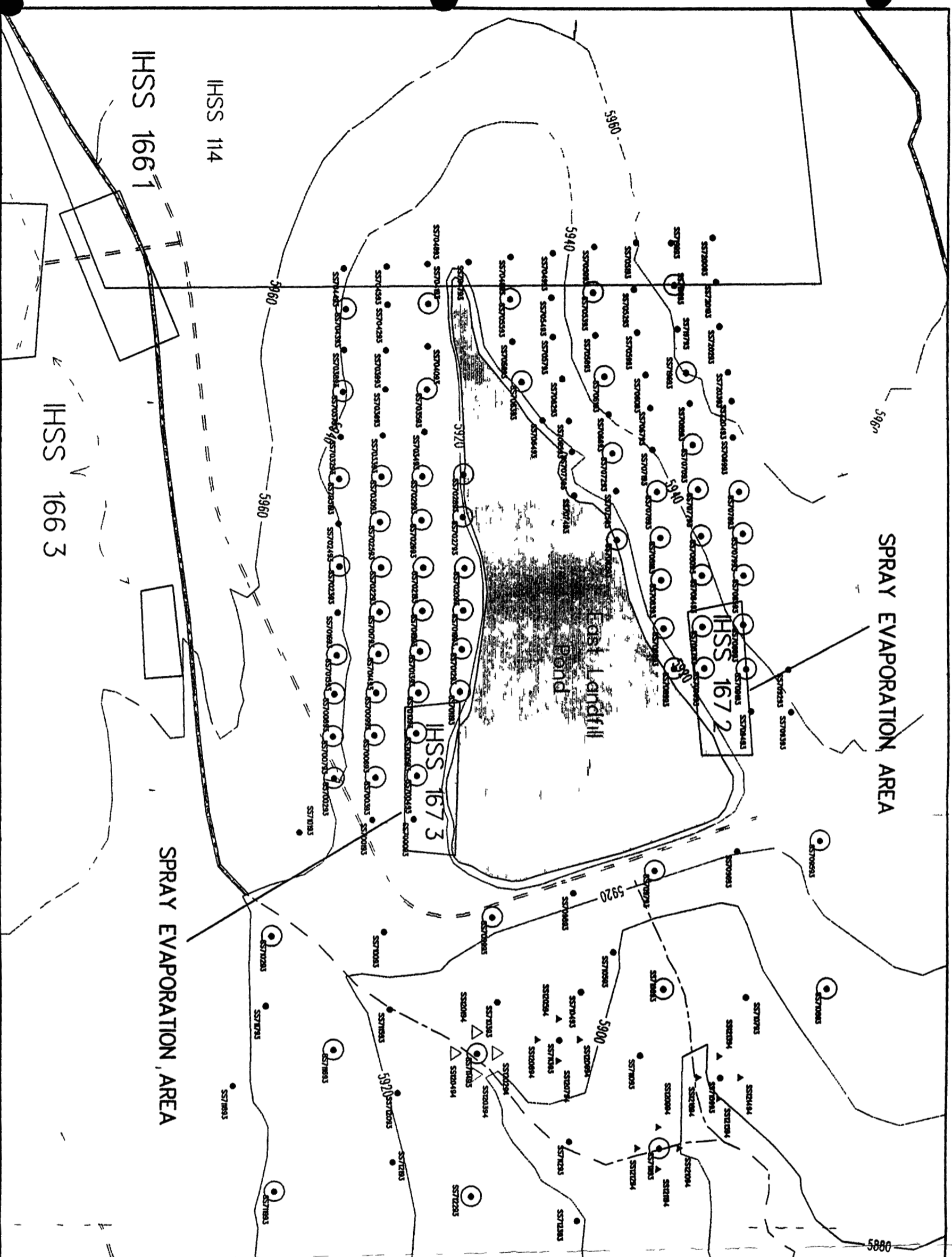
W/100/1000 DD

Closure Strategy

Operable Unit No. 7

July 1995
April 1995

Figure 8C



EXPLANATION

- Phase I Surface-Soil Sampling Location
- ◄ Phase II Surface-Soil Sampling Location
- Phase I Subsurface-Soil Sampling Location
- ▼ Phase II Subsurface-Soil Sampling Location

--- Intermittent Stream

Dirt Road

Surface—Water Diversion
Ditch

OU 7 IHSS Boundary

—OU 6 IHSS Boundary



Topographic Contour Interval = 20 Feet

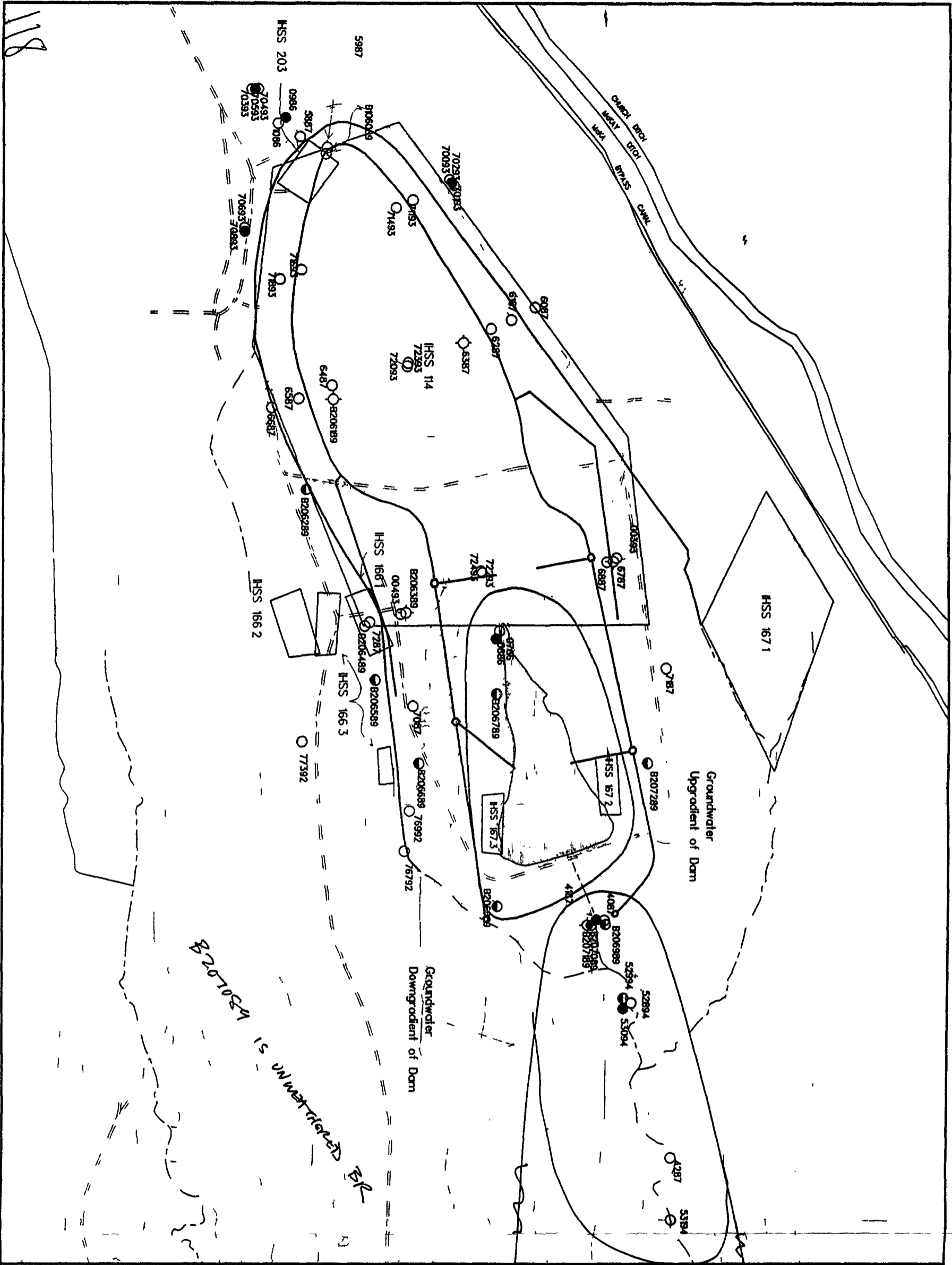
U.S. DEPARTMENT OF ENERGY
Rocky Flats, Site Golden, Colorado

Unimodal Tech, 697
Phase 1 and Phase 4

Soil-Sampling Locations in the ~~at~~ Vicinity of Spray Evaporation Areas

1 m / 128 feet DTD
~~Closed Strategy~~
Operable Unit No 7

July 1995 April 1995	Figure 48 2-105
------------------------------------	----------------------------



EXPLANATION

- Alluvial/Artificial Fill Well
- Weathered Bedrock Well
- Unweathered Bedrock Well
- ◇ Abandoned Well

— Ditch

--- Intermittent Stream

— Dirt Road

— OU 7 IHSS Boundary

— OU 6 IHSS Boundary

— Landfill Structures

— Population of Site



Topographic Contour Interval = 20 feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Site Golden, Colorado

Engineering Technical Unit 17
Downgradient

Groundwater Monitoring
Well Network Location

in/let left DID
Closure Strategy

July 1995
April 1996

Figure 2-18

STET

- Alluvial / Artificial Fill Well
- Weathered Bedrock Well
- Unweathered Bedrock Well
- ~~Abandoned Wells~~

Intermittent Stream

~~OU 7 HSS Boundary~~

~~2006 MISS Boundary~~

~~Landfill Structures~~

Reproduction of Data
Papers



Topographic Contour Interval = 20 Feet.

U.S. DEPARTMENT OF ENERGY
Rocky Flats Site, Golden, Colorado

~~Just before~~
~~06-7~~

Groundwater Monitoring Well Network Layout

11/1/24 DD
~~Chengcheng~~

Operable Unit No 7

July
April 1995

Furco 4250

04/11/95 STATWATERMAP

267

DELETE ALL MENS UNDER 2

11

6-2

EXPLANATION

- Alluvial/Artificial Fill Well
- Weathered Bedrock Well
- Unweathered Bedrock Well
- Abandoned Well

- Ditch
- Intermittent Stream
- Dirt Road
- OU 7 HSS Boundary
- OU 6 HSS Boundary
- Landfill Structures

Regulation of Data



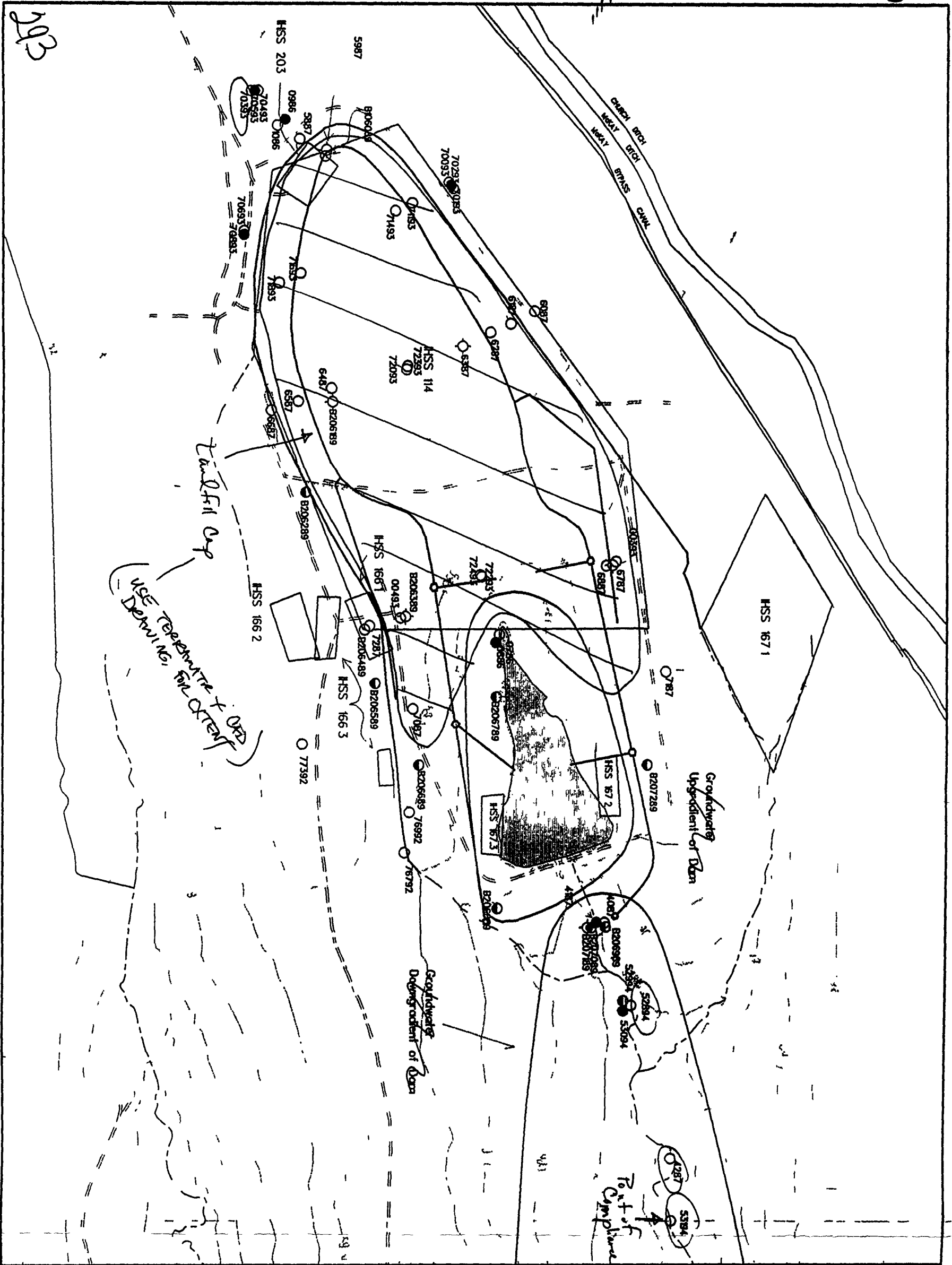
Topographic Contour Interval = 20 feet
(Elevation in feet)

U.S. DEPARTMENT OF ENERGY
Rocky Flats Site Golden, Colorado

Post-Closure
~~OU 7~~
Groundwater Monitoring
Well Network

Rev. 04 DD
Change Strategy Operable Unit No. 7

July
April 1995 Figure 8-1



Landfill Cap
Removal of Well
Removal of Well

DELETE MOUNT
WELLS

ADD CUREN
REPAIRING